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ABSTRACT

This report describes a project developed by the American National Metric Council (ANMC) to assess the effectiveness of the parent-through-child learning model as a method of transmitting metric knowledge. The model used has been in effect in one classroom in El Cajon, California since 1974. An elementary level classroom teacher there initiated and implemented an effective program of teaching metrics to parents of 4th, 5th, and 6th grade students. This investigation reports on the model as implemented at the Cannon Road Elementary School in Silver Spring, Maryland. Four of five teachers of grades five and six mathematics participated. Statistical analysis of data shows all groups of learners increased their metric knowledge significantly as a result of participation. The only possible exception was male parents, whose mean pretest score was the highest of any group. Additional research is viewed as necessary to provide insight into the learning process which occurred at home. It is not known whether children actually taught parents or whether adults gained knowledge from self-instruction. It is felt that with some modification, the instruction model could easily be duplicated in other parts of the country, with assurance that substantial gains in metric knowledge would be achieved. (MP)

SE

Parent-Through-Child Learning Project

This report is made pursuant to Contract No. 400-81-0005. The amount charged to the Department of Education for the work resulting in this report is $24,480. The name of the person responsible for the content of this report is:

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The American National Metric Council is pleased to submit the final report of Contract 400-81-0005, the "Parent-Through-Child Learning Project," to the National Institute of Education.

Due to a variety of factors, the final report reflects several changes in methodology from that of the proposal. Each modification was approved by our panel of consultants and also the Project Officer.

We hope that the recommendations for improving the parent-through-child model and suggestions for additional research will be investigated and implemented in the near future.

We would like to express our appreciation to Dr. Thomas E. Rowan, Coordinator, Elementary Mathematics, in the Montgomery County (MD) Public Schools; to Mr. Francis P. Sweeney, principal; and to Mrs. Marlene Collins, Mrs. Lee Ann Kaye, Ms. Donna Oliger and Mrs. Ann Thomas, teachers at Cannon Road Elementary School. The project was significantly enhanced by their perceptive comments and suggestions.

We would also like to thank Doris Ritchey, a teacher at the Anza School in El Cajon, California, who has encouraged her students to provide metric instruction for their parents each year since 1974. Several of her ideas have been included in the development of this project.

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INTRODUCTION

The Parent-Through-Child Learning Project was developed by the American National Metric Council (ANMC) to assess the effectiveness of the parent-through-child learning model as a method of transmitting metric knowledge. The research was based on the assumption that students in the primary and secondary grades are learning the metric system as an integral part of the total school curriculum and, in many cases, are able to use the metric system with ease. Adults, however, as indicated by a 1977 Gallup poll, exhibit a great lack of knowledge and ability to use the system.

This lack of knowledge is problematic in light of our nation's continual encouragement of voluntary conversion to the metric system. In addition, recent research (one study conducted in May, 1980 by King Research of Rockville, Maryland and a second conducted by three university professors and published in the Journal of the Society for Advancement of Management, Spring, 1980) has indicated that metric conversion is evident in a wide variety of industries. For example, 62% of all Fortune 1000 firms produce at least one metric product and 34% of new products were using metric design. General Motors is currently 98% metric and is scheduled to be 100% metric by 1982. All wine and distilled spirits are now bottled in metric-dimensioned containers. Most soft drinks are marketed in one and two liter plastic bottles and tires are now being designed to metric specifications.

The Parent-Through-Child Learning Project was developed with the following objectives:

-- to increase the metric knowledge of parents of 5th and 6th grade students in one school;

-- to give the students themselves added practice and experience with the metric system to prepare them to teach metric skills to their parents;

-- to give both groups of learners "hands-on" experience with the metric system;

-- to provide parents with the basic terminology which they will need in the future;

-- to assess the effect of various attitudinal variables (such as feelings towards math, the metric system and participation in this project), on knowledge acquired;

-- to identify particular characteristics of parents who began the project but failed to complete the post-test ("drop-outs"); and

-- to create a model which could be easily duplicated for the teaching of metrics, or other subjects, to adults utilizing the parent-through-child method.

Several additional benefits were expected to result from the project:

-- familiarizing parents with the methods and content of their children's learning on a day-to-day basis;

-- increasing the number of consumers (parents) prepared for metric conversion; and

-- establishing a series of activities, emanating from the school and aimed towards the enhancement of parent-child interaction.

The parent-through-child learning model has been in effect in one classroom in El Cajon, California since 1974. Initiated and implemented by an elementary level classroom teacher, the model has been very effective in teaching metrics to parents of 4th, 5th, and 6th grade students. The 26 adults who completed the pre-test in 1981 had an average score of 52%, and 22 members of that group who took the post-test, raised their average to 84%.

Thirty-five students in the class achieved a pre-test average of 26% and a post-test score of 82%, only slightly below parents. The success of this model motivated ANMC's development of a more in-depth analysis of this method of instruction.

This parent-through-child learning model was implemented at Cannon Road Elementary School in Silver Spring (Montgomery County), Maryland. Located in the suburbs of Washington, D.C., this public elementary school had an enrollment of 366 students in kindergarten through grade 6 during the 1980-81 school year. Cannon Road teachers had provided some metric instruction each year since 1975 when the county first included metric objectives in the curriculum. However, ANMC Project Staff were particularly interested in this school because it appeared to have placed a somewhat limited amount of emphasis on metric objectives. (Other schools in Montgomery County participated in a computerized management system which carefully monitered the teaching of all math objectives, including those pertaining to the metric system. It was thought that these schools would have provided a particularly rigorous metric curriculum in past years, and therefore would be too atypical and should not be selected for this pilot project.)

The principal of Cannon Road described his school as being a "continuous progress school:" as children demonstrate mastery of specific skills, they are able to move ahead to the next level of objectives. The school, also as described by the principal, is structured in terms of its ability to offer a well-planned sequential program in all subject areas. All classes in the school are self-contained, with the exception of 5th and 6th grade math.

The <u>15 Year Comprehensive Master Plan for Educational Facilities</u> published by the county, described Cannon Road's population for 1980-81 as being 20.8%

Black, 6.3% Asian and 2.5% Hispanic. The total minority population was listed as 29.5%. Selected California Achievement Test scores for the Fall of 1980 were as follows:

Test	Grade 3 Mean	Grade 3 Percentile Rank	Grade 5 Mean	Grade 5 Percentile Rank
Total Reading	420	78	497	75
Math Comprehension	372	82	471	75
Math Concepts and Application	415	72	491	77
Total Math	396	80	479	76
Total Battery	411	83	490	78

After Project Staff presented an outline of the proposed program, four of the five teachers of 5th and 6th grade math classes at Cannon Road decided to participate. The pupils had already been placed in "average" or "above average" math classes on the basis of teacher recommendation, past achievement and performance on a county test based on grade level objectives. Teachers and school administrators decided that the curriculum, in its present form, would be too difficult for the one class of "below average" math students.

As is true of almost half (49.93%) of the teaching staff in this school system, all teachers participating in this project had masters degrees or a masters equivalency rating. The four teachers had between 17 and 24 years of teaching experience. One teacher had completed all but her dissertation towards a Ph.D. in math education and had taught several inservice metric workshops, and a second had completed several math workshops. The other two teachers had completed only one metric workshop eight years ago and had no additional mathematics experience, beyond that required for certification.

Parents in the Cannon Road community evidenced a similarly high level of education. In response to telephone interviews, 72.15% of the parents indicated that they had been awarded a college degree. This statistic is in line with school publications which describe 15 as the median number of years of schooling for adults in the county. 60.76% of parents describe themselves as having occupations which the Dictionary of Occupational Titles identifies as being in the "Professional, Technical and Managerial" category. When asked if their present occupation utilized mathematical training, 56.96% responded affirmatively. Finally, Project Staff computed that 23.75% of all parents completing the pre-test for this study, achieved scores of at least 75% overall. These parents clearly demonstrated basic knowledge of the metric system before administration of the curriculum, but desired to take part in the project, nevertheless. Perhaps familiarity with the subject and/or an opportunity to work with their children motivated their decision to participate.

PROGRAM DESCRIPTION

At the request of the principal and teachers, Project Staff presented an overview of the parent-through-child learning project in order to help teachers determine their willingness to participate. The teachers had expressed concern that the project would require a substantial amount of time for the preparation of lessons and the teaching of parents as well as children. They were assured that, although they would have an opportunity to review and possibly modify the curriculum, all lessons would be prepared by Project Staff. In addition, Project Staff agreed to assume the responsiblity for acquiring and distributing many of the materials needed for constructing manipulative aids, as well as duplicating all worksheets and tests and correcting those completed by parents.

Teachers and school administrators also received assurance from Project Staff that the learning needs of the students would be of primary importance; if necessary, the requirements of an optimal situation for research would be sacrificed to insure that the program was designed to meet individual student needs. (For example, whereas an optimal research design would require that the curriculum be presented in exactly the same manner to all students, the teachers were free in this case to modify the lessons to some extent to best instruct their pupils).

The four teachers involved were enthusiastic about the project and welcomed the opportunity to learn techniques to use in teaching metrics in the future as well as with their current students. Teachers and Project Staff decided to meet on an average of once per week to review and modify lessons as necessary.

During several of these sessions teachers constructed the manipulative aids that the children would make in class during the following week.

After the teachers decided to participate in the program, a letter describing the project was sent to all parents (Appendix 2). Although the teachers would present the learning activities as part of the regular math curriculum in all four classes, the school system required parental permission for an outside researcher (i.e., Project Staff) to use results from student tests and questionnaires. Parents, therefore, were asked to indicate if their children would be allowed to take the tests, as well as whether they wished to participate themselves. They were also invited to attend a meeting to learn more about the background and objectives of the project.

Parents of approximately 120 students received letters with accompanying permission forms. Of the 80 forms returned to school, 76 parents gave permission for their children to take the tests and one or both parents of 60 children agreed to participate.* Of the 16 parents who returned the form but chose not to learn the metric system, only 2 indicated a lack of time as preventing them from doing so. (Of course, we can assume that the parents who failed to return the permission form lacked the time and/or interest to complete the form or participate in the project.) Five parents who did not participate noted that they knew the metric system already (two parents "use it every day") and were, therefore, not interested in the project. Several additional

*Because three families had more than one child in the program and were therefore not included in the statistical analysis, these figures differ slightly from the table on page 22. In addition, 16 children took the tests for the project but did not teach their parents.

parents agreed to participate if we felt it appropriate, but stated that they already knew the metric system. Parents of children in "above average" math classes chose to participate more than twice as often as parents of children in "average" math classes (59 parents vs. 23 parents).

Within two weeks after indicating a desire to participate, each parent was interviewed on the telephone regarding his or her attitudes toward math, the metric system and enthusiasm for this type of learning (Appendix 4). Although careful analysis of the parents' responses to these questions and post-test scores failed to indicate any relationship between the two (see discussion in next section), Many comments made during the interviews are of intererest.

All but six of the parents who responded to the question regarding the importance of the metric system, felt it was at least "somewhat important" for them to learn it. Those who volunteered reasons for this belief frequently mentioned a desire to help their children with homework and a desire to be knowledgeable about a system of measurement that will be an integral part of their children's world, if not their own. While many expressed the belief that this country should convert to the metric system because "every other country has it," or "it's more logical," others felt a need for more knowledge simply because we are converting "whether we like it or not." Some parents cited the slow pace of conversion as the reason they feel knowledge of the system is <u>somewhat</u>, rather than <u>very</u> important. ("It will be very important for me to learn it <u>if</u> we go metric.")

Most parents were enthusiastic about "learning from their children." One interviewee mentioned that she "does it all the time." A second pointed out that parent-through-child learning is nothing new: her parents had come to the U.S. from Europe and learned to read when their children brought books home from school.

The "Think Metric" theme of the curriculum appealed to many parents. An engineer, describing his experiences of converting from standard to metric with a calculator but having no feel for the sizes of the metric units, was eager to begin measuring. Already enthusiastic about the project, a mother admitted that lessons which emphasized "hands-on" learning experiences would motivate her to learn a subject that would probably be of little interest to her otherwise.

Children were also eager to participate in the project. Comments on a brief questionnaire administered with the pre-test (Appendix 6) indicated that all students were either "enthusiastic" or "not sure" about their involvement. A 6th grader admitted, "I know almost nothing about the metric system and don't know how I'm going to teach my mother but I love math and think it's a great idea." Others expressed more confidence: "I'm happy to teach my parents something instead of them teaching me" and "I think my father and mother will like this alot (SIC); I want to see how much they know."

Immediately after all interviews were completed, teachers administered the pre-test (Appendix 3) to students who, in turn, brought copies home for their parents. All parent pre-tests and worksheets were coded to insure anonymity. It should be noted that pre-test scores were unavoidably affected by awareness of impending participation in the project. Similarly, although interviewers requested that parents refrain from consulting sources of metric information when completing the test, this was impossible to enforce.

Thereafter, teachers presented metric lessons to students during two or three math classes per week for nine weeks (From beginning to end, the project actually spanned eleven weeks. Vacation and county testing accounted for two weeks during this period.) While attempts were made to complete the lessons on the same day in all four classes, the need to share materials and provide student reinforcement of concepts often prevented this.

The curriculum (Appendix 1) reflects modifications that were made as a result of teachers working with the materials and offering suggestions. The lessons were designed to teach the same skills as were assessed by pre- and post-tests. Each unit presents lessons on awareness, technical knowledge (changing from one metric unit of measure to another), and problem solving, in that order. A few related skills which are traditionally taught in the Maryland school system but were tangential to the the thrust of this curriculum, are included under "Notes to the Teacher."

After each lesson, children were asked to teach their parents the concepts presented in class that day. "The Metric System Day to Day", a booklet published by the American National Metric Council (Appendix 11), was sent to parents to be used as a reference. In addition, a section titled "Teaching Notes to 5th and 6th Graders" at the top of each worksheet summarized the basic principles developed in class. If a manipulative aid was constructed in class, children were asked to demonstrate its use at home. Project Staff corrected and returned worksheets completed by parents on a weekly basis, while teachers reviewed their students' work.

The sixty-four parents who completed the project (i.e. completed the post-test) submitted an average of 11.89 worksheets, out of 19 sent home. In spite of the "Think Metric" approach, parent worksheets were sometimes covered with scrawled notations of multiplication and division, indicating conversions from standard to metric units. For example: " what is the length of the room you are now in?" was a worksheet question designed to give parents practice using a meter stick and help them develop a feel for metric units of length. Notes on one worksheet were as follows: 1 ft. = 12 in. = 2.54x12 = 30.48 cm. 28' = 853.44 cm. Parents apparently often relied on known quantities and tried to "translate," rather than using measuring devices to learn a new "language."

A post-test, identical to the pre-test, was administered to all children and sent home to parents immediately after the learning activities were concluded. (Funding limitations prevented the field testing that would have been necessary to develop two forms or evaluate reliability of the same test.) Parents were also asked to return the time sheet (Appendix 8), designed to provide information regarding the amount of time parents devoted to the activities each week. As only 11 parents returned these sheets, the results were not tabulated. In addition, telephone interviews, for parents and attitude questionnaires for students, (Appendixes 5 and 7) were also administered. Project Staff interviewed sixteen children, all four participating teachers and the Principal to assess reaction and elicit suggestions for program modification.

Reactions to the Project

Children

After completing the post-test, children were asked to respond to the following question: "If your friend had a chance to participate in a project such as this one, what would you advise him or her to do? Why?" While some students would steer peers away from participating, the majority would recommend taking advantage of such an opportunity, ("Teach their parents because it helps you learn better and understand more and most parents don't know the metric system"). Several pupils particularly enjoyed the construction of measuring devices, ("I'd tell them it is very fun and I'd give him advice to do it and I would show him what we made").

The opportunity to teach adults apparently provided children with valuable lessons in responsibility. One student warned: "Always remember to bring home the assignment sheets" and another, "Tell their parents to set aside lots of time for homework at night." A third offered a more specific suggestion based on her experience: "I would advise them to work out a schedule where they have enough time to talk and work with their parents."

Reflecting their teachers' frustration with a curriculum that at times presented many new ideas without allowing adequate time for reinforcement, many students advised friends to "listen at all times, because you might get lost along the way." Children also seemed to learn the importance of an attribute required of any good teacher: "I'd advise him/her to have alot of patience ready because it requires alot." (SIC) At least one child clearly demonstrated that the project was worthwhile: "Yes I would (recommend that a friend participate) because it gives you a chance to know your parent."

To gain additional insight into student reaction to the project and the instructional process operating at home, Project Staff conducted group interviews of sixteen 5th and 6th graders who had taught the metric system to at least one parent. Although interviewees were not randomly selected (teachers were asked to recommend children who would be eager to discuss the project), all sixteen were enthusiastic about parent-through-child learning.

In describing the decision-making process which took place in each family to determine whether to participate in the project, several children mentioned that they had convinced reluctant parents to be their students. In one case, "Dad knew all about metric so Mom participated," in another, "Mom didn't want to do it because she didn't know anything about metrics so my dad did it." In a third family, both parents reportedly wanted to learn, but Mother plans to acquire the knowledge from Father when the project is over, rather than completing the lessons and returning them to school.

The problem of "worksheet accumulation," mentioned repeatedly by parents as well as students, was discussed during the group interviews. Business trips, student and teacher absences, and simple forgetfulness were obstacles which prevented parents from receiving one or two worksheets each week, as originally planned. One student described his desk as being "real messy." ("I shoved a whole bunch of worksheets (to be completed by parents) into my desk. When I cleaned it out, several weeks later, I brought them home.") These delays were frustrating to many parents, and undoubtedly hindered the learning process.

Nevertheless, in many cases students described their parents as fully enjoying metric measurement. Materials that were broken in school or on the way home were often reconstructed with kitchen supplies. ("My mom made two decimeter cubes and I made another one at home.") Parent-child teams also modified suggested measuring devices; a sixth grader used a half-pint milk carton from the school cafeteria to make a displacement bucket, measuring the displaced water with a milliliter eye dropper. While parents often seemed to complete worksheets alone, rather than under the scrutiny of their "instructors," children, according to their own report, eagerly demonstrated the use of manipulative aids and answered questions when parents needed help.

<u>Parents</u>

Seventy-four of the 76 parents questioned at the conclusion of the study responded that they would recommend participation in a similar project to a friend. The majority of the parents who completed the post-test as well as a few who did not return the test ("drop-outs") were interviewed for reactions. Reflecting a general consensus that this method is a good vehicle for introducing the metric system to adults, a father added that he would suggest this mode of learning most enthusiastically to a parent whose knowledge of metrics was minimal. Parents commented repeatedly on the value of the project in enhancing the parent-child relationship. All but 13 of the parents felt that the parent-through-child learning model has the potential for teaching the metric system to adult learners.

For several reasons, failure to devote time to metric activities and complete worksheets were mentioned as major problems by the majority of participants. Evening work, community involvement and the demands of overly scheduled lives all impeded parents and children attempting to learn the metric system at home. Most parents blamed themselves. ("This was a deficiency in myself. I should have been more steadfast," and "We got behind. It was our fault.") Although they had committed themselves to participate with the knowledge that they would be asked to devote approximately one-half hour twice per week, the problem was described repeatedly, clearly indicating a need for program modification.

Similarly, many parents relying on their children to bring home worksheets and materials, were often frustrated. As described by the children, worksheets became lost in desks or book bags somewhere along the lengthy routes from school, to home, back to school for corrections and home again to allow parents to review their errors (One mother found five completed sheets in his notebook that her son had failed to give to his teacher.) While test scores clearly indicated that parents did acquire metric knowledge, a more dependable flow of information would undoubtedly have enhanced the learning process.

The nature of the parent-child relationship was frequently mentioned as a factor in determining the success of the project. While some parents were pleased to have a prescribed time to study with their children ("when you work with your own child, it's enjoyable"), others found this learning situation difficult. One father who was very enthusiastic about the program ("I would do it again if you have another program") mentioned that he ordinarily spends a lot of time on assignments with his daughter. She was conscientious about bringing metric worksheets home and finding time to work together was no problem. This type of parent-child activity was clearly part of their lives before the project and, therefore, fit into their schedules without difficulty. Perhaps the father, during previous tutorial sessions had modeled behaviors which this student was able to effectively imitate as a teacher of metrics. Conversely, other parents found the "nature of the relationship between small children and parents is not good for learning."

Not surprisingly, many parents described a lack of interest and even fear in anything mathematical as limiting the knowledge they acquired. Parents complained that the worksheets involved "too much math and not enough metric." A writer admitted that she had successfully used the metric system when living in another country, and even found it easier than customary measurement, but had forgotten how to use metrics and was simply not interested in anything to do with math. Another parent described himself as "not inclined to math at all" and a third admitted that, "math is not my forte." Clearly, these concerns need to be addressed by any program which attempts to impart metric knowledge to the general public.

As described above, the population utilized for this pilot represented a wide range of educational experience and mathematical training. As a result, the lessons, while appropriate for most of the children and the majority of their parents, were described as "very difficult" by a few adults and "perhaps too simple" by several others. Two parents noted a need for more review and reinforcement, while several others suggested eliminating some of the worksheets for parents, finding many of them "tedious." The wide range of parent knowledge resulted in part from a policy of encouraging all parents to participate, even if they mentioned in advance that they knew the metric system but were interested in participating to help their children.

In spite of these problems, 38 of the parents interviewed at the conclusion of the project felt that they had a good concept of the metric units (such as centimeters, grams and kilograms), and 44 felt comfortable changing from one metric unit to another (such as from centimeters to meters). Page 39 describes responses to other questions posed during these interviews.

Teachers

The four teachers who taught the curriculum agreed that students had received an excellent exposure to the metric system and plan to repeat many of the activities in future years. They also agreed that the program had enhanced their metric teaching skills and felt that little or no extra preparation time had been required. All responded that they would recommend participation in a similar project to other teachers.

Although curriculum guides in this school district have included metric objectives at the elementary level since 1975, teachers emphasized that many of their students lacked the skills and experience necessary to move at the pace outlined in the curriculum. Teachers provided extra worksheets to reinforce concepts but still felt that devoting time to metric constructions, while a strong point of the program, prevented the discussion and review necessary for all students to fully master the material. They suggested that teaching the metric system at the very end of the school year, as was the case in this pilot, made it difficult to commit additional time when necessary. They also noted that too many special projects compete for attention in the Spring.

The children's involvement in teaching metric concepts to their parents seemed to have little effect on their classroom experience. Teachers found student interest in the initial role-play activities (Lesson 1 of curriculum, Appendix 1) to be low and suggested including more of these sessions after youngsters had an opportunity to work with their parents and become motivated to learn teaching techniques. Because teachers did not correct worksheets completed by parents nor did they keep records of parent progress, their involvement with parents was minimal. While it is certainly necessary to minimize the work required of teachers who participate in similar endeavors, methods of improving parent-teacher communication should be explored.

Principal

Reflecting the attitudes expressed by the teachers on his staff, the principal was enthusiastic about the project's novel presentation of metric concepts and supported the program as a school initiated activity for parent-child interaction. He emphasized the importance of having Project Staff who work closely with teachers and are willing to modify the curriculum to meet the demands of scheduling conflicts and the learning needs of students.

Somewhat surprisingly, the principal received no feedback from parents, regarding the project. Apparently, from the perspective of the parents, the involvement of an outside researcher removed the project from the principal's domain. The principal questioned the effectiveness of the parent-through-child learning model in teaching the metric system to adult learners, noting that adults learn in a manner similar to children, i.e. when they have a need for knowledge. He agreed that parents would learn more readily if legislation mandating conversion to the metric system were imminent. He noted that, at the present time, parents are motivated primarily by a desire to help their children and understand what is being taught in school. Nevertheless, he would recommend the program to another principal, particularly with the modifications that result from this study.

STATISTICAL ANALYSIS

The primary objective of the project was to ascertain the effectiveness of a parent-through-child learning model as a method of transmitting metric knowledge to children and their parents. Initially the analysis focused on the question of whether the increases in scores from pre-to post-test were significant for all parents and children, as well as for specifically chosen subgroups. Because both pre-and post-tests were composed of separate sections testing awareness, technical knowledge and problem solving ability, correlations between the three pre-test and the three post-test scores, were also determined.

In addition, the data was analyzed to determine whether those children whose parents chose not to participate differed in any way from the group of children whose parents took an active role in learning the metric system. Finally, it was desired to assess any relationships which might exist between the amount learned and certain personal characteristics and attitudes of participants as determined by telephone interviews (for the parents) and attitude questionnaires (for the children).

As described above, parents were required to give permission for their children to take the tests designed for this project and also decide whether to participate themselves. Not surprisingly, some parents agreed to learn the metric system, completed the pre-test but failed to complete the post-test, thus becoming "drop-outs." As a result of this organization, each family in the study can be classified as a member of one of the following four mutually exclusive and jointly exhaustive categories: "Two participating parent" families (2PP) were those for which the child and both parents completed both pre-and post-tests. "One participating parent" (1PP) families were those for which the child and one parent completed both tests. (This group included those families in which one of two parents dropped out of the study before completion). "Drop out parent" (DOP) families were those for which one or two parents entered the study and took a pre-test but "0" parents completed the study, (i.e. they did not take a post-test). "No participating parent" (NPP) families were those for which parents allowed their children to take the tests but never participated themselves. In all four cases the child completed the program.

Each test score, pre or post, parent or child, is a trivariate random vector, with pre-test scores denoted by $\underline{X} = (X_1, X_2, X_3)$ and post-test scores by $\underline{Y} = (Y_1, Y_2, Y_3)$. The difference between the respective scores are denoted by $D_i = Y_i - X_i$, for $i = 1, 2, 3$ with $\underline{D} = (D_1, D_2, D_3)$. The sum of the pre-test scores is denoted by $PRES = X_1 + X_2 + X_3$, and the sum of the post-test scores by $POSTS = Y_1 + Y_2 + Y_3$. Sixteen attitudinal variables obtained through interviews and questionnaires, as well as other classificatory variables such as the sex of each individual parent or child and the math class level of the child (either "average" or "above average") were included in the data base.

A comparison of pre- and post-test scores comprised the initial portion of the analysis. For each of the subgroups listed in Table 1 the mean and standard deviation for both PRES and POSTS are given, except for the "drop-out" category whose members failed to complete the post-test. In addition, a Hotellings T^2 Test was performed for each subgroup to determine whether there was a significant increase in average test score. This is a multivariate test based upon the differences $\underline{D}$ and the estimated covariance matrix of the differences, and it tests the hypothesis that $m_1 = m_2 = m_3 = 0$, where m_i denotes the theoretical mean of the difference D_i, for $i = 1, 2, 3$.

Table 1
COMPARISON OF PRE- AND POST-TEST SCORES

GROUP	# IN GROUP	PRE-TEST MEAN	PRE-TEST STANDARD DEVIATION	POST-TEST MEAN	POST-TEST STANDARD DEVIATION	HOTELLINGS T^2	P-VALUE
PARENTS:							
All Parents Completing Project	64	28.703	7.837	34.391	5.865	46.58	< .00001
Male Parents	31	32.161	6.895	36.032	4.183	6.32	.06244
Female Parents	33	25.485	7.383	32.848	6.801	66.30	< .00001
1PP Family Parents	28	28.393	7.177	34.179	5.200	18.85	.00102
2PP Family Parents	36	28.972	8.429	34.556	6.403		
Drop Out Parents	16	24.812	7.705				
CHILDREN:							
All Children	73	18.603	6.658	29.137	5.893	223.89	< .00001
Male Children	32	18.875	7.228	29.438	5.831	91.80	< .00001
Female Children	41	18.390	6.261	28.659	5.994	147.01	< .00001
Children In Above Average Math Classes	51	19.412	7.049	30.353	5.295	168.35	< .00001
Children In Average Math Classes	22	16.727	5.329	26.318	6.357	62.62	< .00001
Children Whose Parents Dropped Out	11	15.545	6.186	25.455	5.820	60.43	.00015
Children Whose Parents Did Not Participate	16	18.375	6.592	29.688	5.712	51.58	.00003

27 (Tests included 40 items) 23

In addition to the subgroups listed on Table 1, T^2 tests were performed for children who taught both of their parents ($T^2 = 34.87$, $n = 18$, $p = .00013$) and children who taught one parent ($T^2 = 101.45$, $n = 28$, $p < .00001$).

The data show a very significant increase in the average test score for all groups considered, except possibly for male parents whose PRES of 32.161 was the highest of any subgroup considered. We note at this point that the large number of hypotheses being tested here would cause any pre-set significance level 'p' used for each test to generate an experiment-wise error rate equal to some large multiple of p. Hence a p-value must be extremely small to give convincing evidence of the falsity of a particular hypothesis. For example, using Bonferroni's inequality, ten tests each performed at level .005 have a simultaneous level of, at most, .0489. We will be rather conservative in our testing, therefore, in what follows and use .005 or even .001 as a standard value of significance.

In Table 2 the means and standard deviations for each of the three pre- and post-test scores of thirteen subgroups of students and parents are given. Note that X_1 and Y_1 represent the metric awareness portion of the test, X_2 and Y_2 the technical knowledge section (questions regarding the process of converting from one metric unit to another), and X_3 and Y_3 the problem solving subtest.

Table 2

Means and Standard Deviations, Pre- and Post-Test Scores

Standard Deviations (in parentheses) are below mean scores

	N	X_1	X_2	X_3	Y_1	Y_2	Y_3
Total items on test		20	14	6	20	14	6
Parents							
All parents completing project	64	14.563 (3.866)	10.172 (3.471)	4.000 (1.285)	17.547 (2.588)	12.078 (2.858)	4.609 (1.487)
Male parents of 1PP families	13	15.231 (3.961)	12.077 (1.891)	3.923 (1.188)	17.538 (2.367)	12.846 (1.463)	5.077 (1.112)
Female parents of 1PP families	15	13.333 (3.222)	8.867 (3.159)	2.733 (9.612)	17.0 (3.024)	11.867 (2.446)	4.2 (1.474)
Male parents of 2PP families	18	16.556 (3.698)	11.778 (2.602)	4.50 (1.295)	18.278 (2.081)	13.167 (1.425)	5.0 (1.188)
Female parents of 2PP families	18	13.111 (3.740)	8.278 (4.041)	3.722 (1.364)	17.278 (2.845)	11.167 (3.792)	4.222 (1.865)
Drop-Out parents	16	12.250 (3.786)	9.125 (3.998)	3.438 (1.263)			
Children							
All children	73	9.986 (3.422)	6.014 (3.007)	2.466 (1.179)	15.151 (2.942)	10.534 (2.839)	3.315 (1.363)
All male children	32	10.344 (3.460)	6.063 (3.426)	2.468 (1.270)	15.406 (3.004)	10.313 (2.967)	3.406 (1.388)
All female children	41	9.7073 (3.408)	5.976 (2.679)	2.463 (1.120)	14.951 (2.915)	10.707 (2.759)	3.244 (1.356)
Male children of drop-out parents	6	9.167 (4.309)	5.0 (3.578)	2.333 (.816)	14.5 (3.987)	8.833 (3.656)	3.0 (.894)
Female children of drop-out parents	5	7.0 (1.414)	5.40 (2.302)	2.0 (1.0)	13.60 (2.302)	8.40 (1.949)	2.40 (1.140)
Male children of non-participating parents	5	10.60 (4.037)	7.20 (4.324)	2.0 (1.581)	16.60 (3.130)	11.40 (2.608)	4.20 (1.483)
Female children of non-participating parents	11	9.273 (2.453)	5.182 (2.639)	2.364 (1.027)	14.455 (2.296)	9.909 (3.015)	2.250 (1.844)

Table 3 gives mean percentages, on the three pre- and post-tests for each of the subgroups considered.

Table 3

Mean Percentages, Pre- and Post-Tests

	N	X_1	X_2	X_3	Y_1	Y_2	Y_3
Total items on test		20	14	6	20	14	6
All parents completing project	64	72.82%	72.66%	66.67%	87.74%	86.27%	76.82%
Drop-out parents	16	61.25%	65.18%	57.30%			
All children	73	49.93%	42.96%	41.10%	75.76%	75.24%	55.25%
All male children	32	51.72%	43.31%	41.15%	77.03%	73.66%	56.77%
Male children of non-participating parents	5	53.0%	51.43%	33.33%	83.0%	81.43%	70%
All female children	41	48.54%	42.69%	41.05%	74.76%	76.48%	54.07%
Female children of non-participating parents	11	46.37%	37.01%	39.40%	72.28%	70.78$	37.50%

It can be concluded from Tables 2 and 3, that all groups of parents demonstrated greater knowledge of the metric system than the children, on all sections of both pre- and post-tests. Parents who subsequently dropped out of the project demonstrated slightly lower pre-test scores on all sections than those parents who completed the post-tests.

Problem solving proved to be the most difficult section both before and after the metric lessons, for all groups, with the one exception of pre-test scores for female children of non-participating parents. The low scores on this section indicate a possible need to reexamine the test carefully and eliminate those items which may be confusing or misleading. More generally, it would appear that additional methods of teaching problem solving skills to both groups of learners ought to be explored.

While female children whose parents did not participate in the project had pre- and post-test scores that were slightly lower than female children whose parents did participate, males who did not teach their parents scored higher than males whose parents were in the project on five of the six sections.

Since test scores showed a statistically significant increase for all groups of participants, the correlations among the three section scores for several groups of learners were investigated. For children and also for parents in two-participating-parent families, correlation matrices for pre-test X (Table 4) and post-test Y (Table 5) are given below. The p-value associated with the test of whether the particular (theoretical) correlation is given below each observed correlation, and all values are (nonparametric) Spearman's rank order correlations, since the raw scores X or Y, are discrete variables.

Table 4

Spearman's Correlations, Pre-Test Scores, Two-Participating-Parent Families

	Childen			Parents		
	X_1	X_2	X_3	X_1	X_2	X_3
X_1	-	.6578 (.002)	.3868 (.056)	-	.8137 (.001)	.7149 (.001)
X_2	-	-	.6156 (.003)	-	-	.7016 (.001)
		(n=18)			(n=36)	

Table 5

Spearman's Correlations, Post-Test Scores, Two-Participating-Parent Families

	Children			Parents		
	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Y_1	-	.4286 (.038)	.4939 (.019)	-	.6132 (.001)	.3247 (.027)
Y_2	-	-	.1799 (.238)	-	-	.3031 (.036)
		(n=18)			(n=36)	

Tables 6 and 7 correspond to Tables 3 and 4, computed here for one-participating-parent families.

Table 6

Spearman's Correlations, Pre-Test Scores, One-Participating-Parent Families

	Childen			Parents		
	X_1	X_2	X_3	X_1	X_2	X_3
X_1	-	.4603 (.007)	.2462 (.103)	-	.7770 (.001)	.7081 (.001)
X_2	-	-	.1305 (.254)	-	-	.5982 (.001)
		(n=28)			(n=28)	

Table 7

Spearman's Correlations, Post-Test Scores, One-Participating-Parent Families

	Children			Parents		
	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Y_1	-	.4489 (.008)	.5769 (.001)	-	.4297 (.011)	.3091 (.055)
Y_2	-	-	.3429 (.037)	-	-	.6688 (.001)
		(n=28)			(n=28)	

The three pre-test scores in general showed significant correlations among themselves for both parents and children, as did the post-test scores. The most significant correlations, i.e. those having p values $< .0005$ correspond to the following pairs:

(X_1, X_2), (X_2, X_3) children of two-participating-parent families

(X_1, X_2), (X_1, X_3), (X_2, X_3) parents of two-participating-parent families

(Y_1, Y_2) parents of two-participating-parent families

(X_1, X_2), (X_1, X_3), (X_2, X_3) parents of one-participating-parent families

(Y_1, Y_3) children of one-participating-parent families

(Y_2, Y_3) parents of one-participating-parent families

Examination of the above list shows that eight pairs of pre-test scores are among the most significant correlations, while only three sets of post-test scores are included. Thus the strong correlations between pre-test scores, particularly for the parent tests, are to some extent lessened after completing the metric curriculum. Noting again the mean values and percentages given in Tables 2 and 3, it would appear that the comparatively small increases in scores from pre-to post-test in the problem solving (Y) section may account for this weakening of high pre-test correlations.

The next analyses focused on the correlations between PRES and POSTS for children and parents.

Table 8 gives Pearson's correlations for all pairs among the PRES and POSTS for children and parents of two-participating-parent families with the suffix 'C' denoting the child, 'P1' denoting parent #1 and 'P2' denoting parent #2. As above, p-values are given in parentheses below the computed correlations. Note also that P1 denotes the male and P2 the female parent.

Table 8

Pearson's Correlations, PRES and POSTS, Parents and Children of Two-Participating-Parent Families

	PRESC	POSTSC	PRESP1	POSTSP1	PRESP2	POSTSP2
PRESC		0.7297 (0.000)	-0.0278 (0.456)	0.0907 (0.360)	0.2227 (0.187)	0.4621 (0.027)
POSTSC			-0.2218 (0.188)	-0.0946 (0.354)	0.1460 (0.282)	0.2382 (0.171)
PRESP1				0.8543 (0.000)	0.0881 (0.364)	0.2919 (0.120)
POSTSP1					0.658 (0.392)	0.4476 (0.031)
PRESP2						0.5346 (0.011)

(n=18)

Table 9 gives Pearson's correlations, with accompanying p-values in parentheses, for PRES and POSTS for children and parents of one-parent families, with the suffixes 'C' denoting the child and 'P' the parent.

Table 9

Pearson's Correlations, Pre- and Post-Test Sums, Parents and Children

	PRESC	POSTSC	POSTSP	PRESP
PRESC		0.6572 (0.000)	0.3414 (0.038)	0.1896 (0.167)
POSTSC	(n=28)		0.0459 (0.408)	(0.0913) (0.322)
POSTSP				0.7357 (0.000)

The PRES was in general significantly correlated with the POSTS for all groups. The most significant correlations, i.e. those having p-values $<.005$ correspond to the pairs:

(PRES, POSTS) children two-participating-parent families

(PRES, POSTS) male parents, two-participating-parent families

(PRES, POSTS) children one-participating-parent families

(PRES, POSTS) parents, one-participating-parent families

We note also that the POSTS for children are not highly correlated with the POSTS for parents in either family type considered.

Pearson correlations of PRES and POSTS were also computed for the following groups (Tables are included in Appendix 9):

Parents and male children, two-participating-parent families

Parents and female children, two-participating-parent families

Parents and male children, one-participating-parent families

Parents and female children, one-participating-parent families

The most significant correlations found in this analysis are those for (PRES, POSTS) male children two-participating-parent families and (PRES, POSTS) male children, one-participating parent families, generally supporting the conclusions described above.

The correlations resulting from these tests motivated the performance of three multiple regressions. We were interested in assessing possible linear relationships between (POSTS), considered as the response, or dependent variable with (PRES) and number of worksheets completed (NWK), used as independent variables.

The first analysis focuses on predicting POSTS of parents. Denoting post-score and pre-score sums of a parent by POSTSP and PRESP, respectively, the following model was fit for the group of all parents:

$$POSTSP = b_o + b_1 (PRESP) + b_2 (NWK) + e$$

The fitted equation gives the estimates $\hat{b}_o = 17.556$, $\hat{b}_1 = .453$ with a standard error of .06445, $\hat{b}_2 = .323$ with a standard error of .08425. The multiple $R^2 = 57.79\%$ and the F statistics for $\hat{b}_1$ and $\hat{b}_2$ are, respectively, 49.475 and 14.679, both on (1,61) degrees of freedom, for p-values which are $< .001$ in both cases. We conclude that PRESP and NWK are of significant value in predicting POSTSP, for the group of all parents.

Secondly, we were interested in a model which could be used to predict POSTS of children from one-participating-parent families. Post-score and pre-score sums of a child are denoted by POSTSC and PRESC, respectively. The following model was fit for the group of one-participating parent families:

$$POSTSC = b_o + b_1 (PRESC) + b_2 (PRESP) + b_3 (NWK) + e$$

The fitted equation gives the estimates $\hat{b}_1 = .663$ with a standard error of .18979, $\hat{b}_2 = -.060$ with a standard error of .14750 and $\hat{b}_3 = -.027$ with a standard error of .13078. The multiple $R^2 = 66.10\%$, and the three F-statistics are 12.219, .164 and .043 for $\hat{b}_1$, $\hat{b}_2$ and $\hat{b}_3$, respectively, each on (1, 24) degrees of freedom. The respective p-values are .003, $>.5$ and $>.5$. This gives conclusive evidence that PRESP and NWK are of no value in predicting POSTSC for one-parent families, and that PRESC is the obvious choice as a predictor of POSTSC. Note that $\hat{b}_2$ and $\hat{b}_3$ are even negative. The reduced model

$$\text{POSTSC} = b_o + b_1 \text{ (PRESC)} + e$$

yields $\hat{b}_o = 15.421$, $\hat{b}_1 = .695$ with a standard error of .15623, a multiple $R^2 = 65.72\%$ (very nearly the value for the previous model including the two spurious predictors) and an F-statistic of 19.763 on (1, 26) degrees of freedom, for a p-value $<.001$.

The next regression pertains to POSTS of children from two-participating-parent families. Here PRESP denotes the sum of the PRES values of both parents. The following model was fit for two-participating-parent families:

$$\text{POSTC} = b_o + b_1 \text{ (PRESC)} + b_2 \text{ (PRESPS)} + b_3 \text{ (NWK)} + e$$

The fitted equation gives the estimates $\hat{b}_o = 28.698$, $\hat{b}_1 = .429$ with a standard error of .10058, $\hat{b}_2 = -.074$ with a standard error of .08980, and $\hat{b}_3 = -.052$ with a standard error of .06756. The multiple R^2 is 75.7% with the three F-statistics for $\hat{b}_1$, $\hat{b}_2$, and $\hat{b}_3$ observed to be, respectively, 18.188, .673 and .600, each on (1, 14) degrees of freedom. As in the analogous regression for one-parent families, the model reduces to $\text{POSTC} = b_o + b_1 \text{ (PRESC)} + e$, with $R^2 = 72.97\%$, $\hat{b}_o = 23.65$, $\hat{b}_1 = .416$, and $F = 18.225$ on (1, 16) d.f. for a p-value $<.001$. As for one-parent families, PRESC is the best (and the only useful) predictor of POSTSC.

Finally, we focused on children whose parents dropped out of the study, and those whose parents did not participate at all. The following model was fit for children whose parents dropped out of the study:

$$POSTSC = b_o + b_1(PRES) + e$$

The fitted equation gives the estimates $\hat{b}_o = 11.755$ and $\hat{b}_1 = .881$ with a standard error of .10978. The multiple R^2 is 86.38% with the F-statistic for $\hat{b}_1$ observed to be 64.44 on (1, 9) d.f. for a p-value < .0001. Again, PRES is a very good predictor of POSTS for children whose parents dropped out.

Similarly, the same model as that for DOP children was fit for the children whose parents did not participate at all.

The fitted equation gives the estimates $\hat{b}_o = 17.082$ and $\hat{b}_1 = .675$ with a standard error of .16060. The multiple R^2 is 52.63% with the F-statistic for $\hat{b}_1$ observed to be 17.66 on (1, 14) d.f. for a p-value between .0005 and .001.

It may be concluded that the results are essentially the same for children whose parents dropped out or did not participate at all. That is, for any subgroup of children, PRES is the only useful predictor of POSTS.

The next set of analyses focuses on the responses to questionnaires and interviews to determine whether the test scores were affected by, or related to, any of the categorical variables. Specifically, a one-way Multivariate Analysis of Variance (MANOVA) was performed for each categorical variable, using $\underline{Y}$ as the response variable with $\underline{X}$ as a covariate, for the group of all children and again for the group of all parents. In each case, the hypothesis being tested is that the average value of $\underline{Y}$, say $\underline{M}_Y = (M_1, M_2, M_3)$, is the same for each category of the particular variable being considered, with any possible effect of the pre-test score $\underline{X}$ first being removed, or controlled. For example, the hypothesis being tested for the question "can you give me an idea of how much you know about the metric system?" which had the three possible responses "quite a bit," "a fair amount," and "very little" is that on the average $\underline{Y}$ was no different for the three subpopulations defined by these responses. That is, $\underline{M}_Y$ was equal across the three groups, on the average and hence unaffected by the parent's stated level or prior knowledge about the metric system.

We note that the subjects self-sorted for each categorical variable, rather than being assigned to the categories as is assumed in the usual MANOVA model. A "random effects," or "variance components," model is thus appropriate here, since the mean effect of each category is properly considered to be itself a random variable. Since this does not affect the testing procedure in the one-way classification, aside from power calculations which are not considered here, no further mention is necessary.

Table 10 lists sixteen categorical variables. Each refers to a question included in a March or June attitude survey (completed by the children) or a March or June telephone interview (administered to the parents). Variables "PM1" (Parent - March - question #1) through PM10 refer to questions 1 through 10 on the telephone interview administered in March (Appendix 4). Similarly, variables PJ1, PJ2 and PJ3 refer to the June interview, and CMQ1 (Child - March - question #1) and CMQ2 refers to the March questionnaire (Appendix 6). "CJQ" is the only listed question which was asked the children after they completed the project, namely "did you enjoy teaching your parents the metric system?"

Table 10

MANOVAs, All Parents, Y = Response With X As Covariate

Categorical Variable	(Approximate) Hotelling's F-Statistic	Degrees of Freedom	p-Value
PM1	.44265	(6,110)	.849
PM2	1.67059	(9,155)	.100
PM3	1.86220	(6,110)	.094
PM4	2.11023	(6,110)	.058
PM5	.37824	(9,161)	.944
PM6	.32982	(6,110)	.920
PM7	.38983	(9,161)	.939
PM8	.84689	(9,161)	.574
PM9	.90215	(9,158)	.525
PM10	1.46925	(6,110)	.195
PJ1	1.90716	(3,57)	.139
PJ2	.67920	(3,57)	.568
PJ3	1.23803	(6,104)	.293
CMQ1	.81588	(6,110)	.560
CMQ2	.36925	(6,110)	.897
CJQ	1.67581	(3,54)	.183

The large p-values for all tests indicate that the average value of $\underline{Y}$ with $\underline{X}$ taken as a covariate, did not change with any of the attitudinal variables recorded. The smallest p-value corresponds to PM4, the item in which parents respond to the question, "how do you feel about participating in this project?" Even this p-value (.058), however, is too large to be considered significant.

None of the corresponding univariate ANOVA's (the three sections of the test investigated separately) were significant, either, with the most extreme values taken by Y_1 for PM4. ($F = 2.9746$ on (2, 58) d.f. for $p = .059$) and by Y_3 for PM3 ($F = 3.40797$ on (2, 58) d.f. for $p = .040$.) Given the large number of tests, these can hardly be considered significant.

The MANOVAs given in Table 11 are for $\underline{Y}$ (post-tests) of children classified by CMQ1, CMQ2, and CJQ.

Table 11

MANOVAs, All Children, Y = Response With X As Covariate

Categorical Variable	(Approximate) Hotelling's F-Statistic	Degrees of Freedom	p-Value	
CMQ1	.51499	(6,98)	.796	
CMQ2	1.21415	(6,98)	.306	(n=73)
CJQ	.18054	(3,49)	.909	

Again, the children's post-test scores are on the average, unrelated to the child's responses to the questions in the March interview, nor are any of the corresponding univariate (test section) ANOVAs significant.

It can be concluded that the amount of knowledge acquired by parents and children is not related to their expressed attitudes concerning the issues explored. It is of particular interest to note that, in addition, neither educational level nor occupational classification of parents is related to test performance.

The final portion of the analyses focused on those parents who dropped out of the study. We were interested in assessing any differences between this group and those parents who completed the project. As was noted in our discussion of Table 3, each average subtest score for drop-out parents was lower than the comparable score for parents who completed the study. In addition to this simple comparison, a more formal test of the hypothesis to test whether the mean of PRES was the same for (the populations represented by) the groups of drop-outs and completers was performed. There were 16 drop-outs having PRES values varying between 8 and 38 with an average of 24.812 and a standard deviation of 7.705, and 64 completers having PRES values varying between 6 and 40 with an average of 28.703 and a standard deviation of 7.837. The (approximate) Z score is 1.800 yielding a p-value of .0718. This indicates that the average PRES score tends to be lower for drop-outs, although the evidence is not conclusive. We next consider the frequency distributions of Completers and Drop-Outs, respectively, for each of the categorical variables considered. For each variable, the observed frequency and corresponding percentage (given in parentheses) is given for each of the two groups. For those variables with the three (coded) values 1, 2, 3, the fourth double column is left blank. Individuals not responding to a question were omitted from that frequency count.

Table 12

Response Frequencies For Categorical Variables, Completers (C) and Drop-Outs (D)

Categorical Variable	Frequencies and Percentages							
	1		2		3		4	
	C	D	C	D	C	D	C	D
PM1	11 (17.2)	2 (12.5)	16 (25)	5 (31.3)	37 (57.8)	9 (56.3)		
PM2	28 (45.2)	7 (43.8)	29 (46.8)	8 (50)	4 (6.5)	0 (0)	1 (1.6)	1 (6.3)
PM3	54 (84.4)	13 (81.3)	8 (12.5)	2 (12.5)	2 (3.1)	1 (6.3)		
PM4	45 (70.3)	12 (80)	15 (23.4)	3 (20)	4 (6.3)	0 (0)		
PM5	40 (62.5)	10 (62.5)	11 (17.2)	0 (0)	11 (17.2)	6 (37.5)	2 (3.1)	0 (0)
PM6	13 (20.3)	2 (12.5)	32 (50)	8 (50)	19 (29.7)	6 (37.5)		
PM7	41 (64.1)	13 (81.3)	19 (29.7)	3 (18.8)	3 (4.7)	0 (0)	1 (1.6)	0 (0)
PM8	2 (3.1)	5 (31.3)	12 (18.8)	3 (18.8)	26 (40.6)	6 (37.5)	24 (37.5)	2 (12.5)
PM9	37 (58.7)	6 (37.5)	11 (17.5)	5 (31.3)	6 (9.5)	2 (12.5)	9 (14.3)	3 (18.8)
PM10	47 (73.4)	10 (66.7)	12 (18.8)	3 (20)	5 (7.8)	2 (13.3)		
PJ1	38 (59.4)	10 (62.5)	26 (40.6)	5 (31.3)				
PJ2	39 (60.9)	6 (40)	25 (39.1)	9 (60)				
PJ3	19 (31.1)	3 (21.4)	36 (59.0)	7 (50)	6 (9.9)	4 (28.6)		
CMQ1	24 (52.2)	5 (31.3)	20 (43.5)	11 (68.8)	2 (4.3)			
CMQ2	18 (39.1)	9 (56.3)	21 (45.7)	4 (25.0)	7 (15.2)	3 (18.8)		

The drop out responses are surprisingly similar to the answers given by those participants who completed the post-test. Only the slightly lower pre-test scores may be said to distinguish the group of drop-outs.

DISCUSSION

The statistical analysis of the data proves conclusively that all groups of learners (excepting possibly male parents, whose mean pre-test score was the highest of any group) increased their metric knowledge significantly as a result of participation in the program. Additional research is necessary to provide insight into the learning process which occurred at home, i.e. whether children actually taught parents or whether adults gained knowledge from self-instruction. With some modification (described in detail below), this model could easily be duplicated in other parts of the country, with assurance that substantial gains in metric knowledge would be achieved.

The program was effective in reaching both fathers and mothers of children of both sexes. Parents apparently felt free to participate with or without a spouse. While children in "above average math classes" participated in greater numbers, 30.14% of the children came from "average math classes."

Pre and post-tests each consisted of three separate sections. While the test scores <u>were</u> highly correlated, both parents and children gained somewhat less knowledge in the area of problem solving than in metric awareness or technical knowledge. Results suggest careful examination of the test items in the problem solving section, as well as exploration of methods to increase the problem solving skills of both groups of learners. (It should also be noted that several questions in this section involved processes that are not specifically taught in this curriculum, such as methods of computing area and perimeter).

The three pre-test scores showed significant correlations among themselves for both parents and children, as did the three post-test scores. The summed pre-test score was, in general, significantly correlated with the summed post-test score, and for children, the former was the only useful predictor for the latter. For parents the number of worksheets completed was also, along with pre-test sum, a useful predictor of post-test sum. Correlations between parent and children post-test sums were, in all cases, weak or negative. Thus, while all groups of learners increased their knowledge significantly, there is no evidence leading to the conclusion that parents actually learned from their children.

The original assumption that children in 5th and 6th grade classes have greater metric knowledge than their parents was, in this case, false. It is interesting to note that the previously described metric project conducted in California also reported that parent pre-test scores were superior to the scores of children (52% parent average; 26% child average). We conclude that it is necessary to equip children with a thorough understanding of metric concepts before asking them to teach their parents.

Also, contrary to expectation, analysis found a slightly lower average of pre-test scores sums to be the only characteristic of parents who eventually failed to complete the project. "Drop-outs" expressed attitudes which were similar to completers regarding such subjects as knowledge of the metric system, math, and eagerness to participate in the project. Were it necessary to predict which parents would "drop-out" of similar project, pre-test scores could be used as an indicator with some assurance.

In addition, analysis of the data indicated that none of the attitudinal variables was related to the post-test score achieved by parents or children. The model is equally effective in teaching parents with varied attitudes, occupations and levels of education. It can be concluded that the responses offered by an adult influence neither the liklihood that he will complete the project nor the amount he will learn.

While the project has been successful in its effort to create a parent-through-child learning model which can be easily duplicated in other schools, there are several existing weaknesses which should be eliminated by modifying the design. The following section describes these weaknesses and offers suggestions for improvements based on interviews with participating parents, students and administrators.

SUGGESTIONS FOR IMPROVING THE MODEL

Analysis of this project has resulted in the identification of two weak links in the transmittal of information that takes place in parent-through-child learning. First, in order for children to feel confident as instructors, they must have thorough knowledge of all the metric information which they are asked to teach. Secondly, parents must be required to complete homework assignments on a regular basis. A carefully designed monitering system must be established to give parents the incentive necessary to complete all lessons as they are presented.

As illustrated above, students who participated in the program demonstrated a lower level of metric proficiency than anticipated. As a result, rather than giving children "added practice" with metric concepts, as was the original objective, it was necessary to expose the students, often for the first time, to all the information they were expected to teach their parents. Because of the strong emphasis placed on the construction of measuring devices, the time alloted did not allow teachers to present in-depth explanations, nor review material as often as necessary to ensure complete mastery. As a result, students sometimes went home feeling unsure of metric concepts. As one parent commented, "My daughter had 80 to 90 percent of the information. It was the 10 to 20 percent that she did not have that created a lack of confidence."

The teachers involved in the project presented several possible solutions to this problem. While they agreed that the curriculum was effective, they strongly recommended adding supplemental material to be used as "extension" for some children and "reinforcement" for others. The curriculum has been revised to include descriptions of supplementary worksheets where appropriate. Teachers also recommended dividing the curriculum into two sections, each including two or three of the units and each with its own pre- and post-test. Parents would be allowed to participate in one or both sessions, each of which could be taught over a six to ten week period. Children might be asked to complete additional worksheets to ensure their understanding of metric concepts before taking ~~home-selected~~ homework papers for parents. Children who feel totally comfortable with metrics are surely better able to convey the simplicity of the system, and help parents to feel at ease -- an important objecive.

To enhance interest in metrics, several special activities could be planned to coincide with home and school study. As with other aspects of the project, these should be specifically geared to the population involved. A metric fair in which parents and children presented special exhibits, were awarded prizes and received media coverage could be organized as a culminating event. At the end of each unit, special speakers whose work or avocations involved metric measurement could be called upon to make presentations. A "homework center" either at school or in a neighborhood center could be staffed one evening each week by adults who would offer help to anyone involved in the project. All of these activities would encourage parents and children to become more involved in the project, thus strengthening the interest of both groups of learners.

Several additional suggestions, while somewhat more difficult to implement, would undoubtedly result in an educational program more specifically designed to meet individual student needs. Based on the model used by universities to employ master teachers as trainers of student-teachers, classroom teachers could receive stipends to participate in a parent-through-child learning project. Teachers could then be paid to attend pre-service and in-service workshops at which time they would modify this curriculum to best teach each of their students, correct work completed by parents, etc. Ideally, the program would be revised to allow students to take home lessons for their parents only after they demonstrated a specified level of proficiency on a test of the concepts to be presented. Thus children would be thoroughly knowledgeable about a subject before teaching their parents.

An improved monitering system, which would require an additional commitment of time from teachers and/or a project director, would greatly improve the effectiveness of this program. As mentioned above, while parents repeatedly blamed themselves for failure to complete worksheets regularly, the problem was prevelant and indicates the need for program modification. Perhaps the least complicated system would provide parents with a description of worksheets and "due dates" before teaching began. This would mitigate the problem of children forgetting or losing worksheets as parents would know in advance when to expect homework. When beginning the program, parents could be asked to designate a specific time each week which they would devote to metric study. In addition, a system of telephone calls to parents who "fall behind" and/or notes on worksheets for parents indicating other sheets that were "past due" could be instituted. If the budget allowed, worksheets could be mailed home and even back to school after completion. Alternatively, parents might be required to complete all previous worksheets before a new one was sent home, thus ensuring that parents still participating were "caught up" in their work. All of these modifications would have the added benefit of fostering improved communication between parents and teachers. Questions regarding the lessons could be answered more quickly and easily.

Two additional problems described repeatedly concerned the season (Spring) selected for the project and the illegibility of "dittoed" worksheets. Several parents and teachers agreed that September or January, when children are inside during the evening and establishing their schedules for the year, would have been a more appropriate time period for the project. (A math administrator, however, cautioned that most schools normally teach whole number processes in the Fall. He identified January or March as better months for measurement). While budget constraints of this project prevented printing the worksheets, a printing process which results in assignment sheets that are clear and "important-looking" is recommended.

Many of the suggestions described above can easily be implemented to modify the existing program. It is hoped that readers interested in testing this model will review the weaknesses we discovered and make changes appropriate to their community.

TOPICS FOR FUTURE RESEARCH

Results of this research indicate the need for additional information to determine whether parents instructed themselves or learned from their children. Face to face interviews of parents and individual discussions with children would be valuable in obtaining descriptions of the home learning process. Metric worksheets and measuring devices might also be sent home to a control group of parents who are instructed not to discuss measurement with their children. In addition, research could determine whether students who know they are responsible for teaching their parents learn more than those who simply learn themselves.

An analysis of test instruments used for this project might be the basis for continued research. Several forms of a metric test could be developed and tested to ensure reliability. Perhaps changing the items on the interview form and attitude questionnaires would result in more dramatic findings.

This study could also be replicated under a variety of conditions. Would the results be similar if urban or rural populations were selected? What would be the effect of eliminating parents who already have knowledge of metric, or of chosing a population of parents who initially demonstrate a minimal awareness of the subject? Perhaps asking students of junior high school age, who presumably are more familiar with metric measurements, to teach their parents would be more effective. The project described previously, which was conducted in California, included metric activities as part of the science curriculum. (The teacher felt that the science program in her school system was more flexible and allowed her to devote more time to metrics). The effect of this change in curriculum area has yet to be determined.

Additional research might focus on the parents in any population who do not respond to initial invitations to participate in the program. A bias of this project was that the population under study consisted of only those parents who chose to become involved. (School regulations permitted Project Staff to contact only those parents who agreed to participate.) Research to determine if the metric knowledge, educational level or attitudes expressed by non-responding parents differed from those of parents who agreed to learn from their children would be valuable.

Recalling that many parents became involved in the project to help their children, it is suggested that the thrust of the program might be changed to "Parents and Children Learning Together." Teachers could present the project as one method available to parents who desire to play a more active role in the school community. Parents who do not have time to volunteer in classrooms nor become active in PTA might be encouraged to view this project as a contribution to the school and also their child's development.

Families Learning Together, a program developed by the Home and School Institute in Washington, D.C., encourages parents to complete brief reading and math "recipes," with children who are in kindergarten through grade six, in an effort to suppement school learning. The program is designed to educate both parents and children and includes a few metric activities. Research which tested the applicability of this approach to metrics on a broader scale would certainly be of interest.

Additional research is suggested to assess whether the initial metric knowledge demonstrated by the group of parents in this field test is typical of the U.S. population. Although the 1977 Gallup poll referred to earlier discovered that adults know very little metrics, our pre-test indicated a mean score of 71.75% for adults completing the project. While, as described above, well-educated, professionally employed parents comprised a large percent of our population, it is possible that their metric knowledge is not atypical. Perhaps the continued exposure to dual labeling, public service announcements and increased usage in industry has succeeded, during the last four years, in raising the metric awareness of adults. A detailed analysis of the metric knowledge of the U.S. population would be most worthwhile.

Finally, since it has now been demonstrated that parent-through-child learning is effective in instructing adults, the model might be applied to many other fields of knowledge. Perhaps school children can effectively transmit consumer information including banking, household budgeting, savings and investment strategies, or teach courses in general health care. One parent who participated in this study wondered how soon it would be possible for her son to clarify the intricasies of the stock market. Exploration of additional applications of the parent-through-child learning model is certainly encouraged.

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Appendix 1
Curriculum

LINEAR MEASUREMENT - UNIT 1

Lesson 1

Objectives

The student will demonstrate an understanding of three of the skills involved in teaching another individual to perform a given task, namely careful explanation, close attention to questions and the frequent need for patient re-explanation.

The student will know the terms meter and centimeter and their symbols. He/She will have a concept of each and their relationship to each other.

The student will be able to measure given distances in meters and centimeters.

Materials

Letter size manila folders (please review directions and cut each folder in thirds before this activity); one for every 3 children
Scissors
Metric rulers
Paper fasteners
Instructions (may be written on the board)
6 instruction slips for role playing situations (to be cut apart and distributed to 6 children)

Activities

1. Give the children a brief overview of the metric project, explaining the five types of measurement to be studied and the fact that the project will be unique in its requirement that some children teach their parents at home after each lesson in school. They will need to check with the teacher each day to make sure they know which materials are to be brought home.

2. Begin the linear unit by reviewing the terms and symbols for meter and centimeter. Emphasize that a centimeter is 1/100th of a meter. Relate this concept to money (a cent). Discuss related rules of correct metric practice.

a) Names of symbols and metric terms begin with lower case letters.

b) The symbols for meter and centimeter are m and cm respectively. They are not abbreviations and are not followed by periods unless they are at the end of a sentence. (Please see page 73 of this curriculum for additional information regarding correct metric practice.)

3. Distribute materials and give children the opportunity to construct folding meter sticks. As this construction is quite difficult, you will probably wish to provide detailed verbal instructions, demonstrating (possibly with the aid of an overhead projector) as you complete your own meter stick. You may wish to have the students mark one strip at a time as they are assembled.

4. Distribute worksheets to students. Before beginning to work on them, have several volunteers role play the following situations to illustrate appropriate teaching techniques for children to use when working with their parents: Give volunteers "instruction slips" for the role plays which describe the roles and behaviors they are to demonstrate for the class (two children will participate in each situation).

a) Situation A

1. You are a parent learning the metric system. You read question #3 on your sheet aloud and then say "I don't know what to do."

2. You are the 5th or 6th grader teaching the metric system. After you see that your parent has a problem with the question, you ask for the necessary materials (book, ruler, etc.) to do the measuring yourself and write the answer on the sheet.

Teacher: Focus discussion on other alternatives for the 5th or 6th grader (giving careful instructions, demonstrating, explaining, encouraging, etc.). Emphasize specific words the 5th or 6th grader could have used to teach the skill.

b) Situation B

1. You are a parent learning the metric system. You measure the door (question 4) and then say, "I measured it. The door is 2 centimeters and 9 meters high."

2. You are a 5th or 6th grader teaching the metric system. After your parent measures, you say, "Good, let's write that down."

Teacher: Focus discussion on the need to listen carefully when teaching. (This parent confused the terms "centimeter" and "meter.") While the children certainly won't be held responsible if parents make errors on their worksheets, they should be encouraged to pay close attention and help them as much as possible.

c) Situation C

1. You are a 5th or 6th grader teaching the metric system. You carefully show your parent the meter ruler you have made and demonstrate the lengths of meters and centimeters. You show your parent that there are 100 centimeters in a meter.

2. You are a parent. You are working on question number 7 and write in an incorrect answer.

Teacher: Focus discussion on the need for patient re-explanation. What could the 5th or 6th grader now say to the parent?

Notes to the Teacher

1. This introductory lesson is unusually long. Please try to reserve enough time (about 1 hour) to include all the activities.

2. You may decide to present only one or two of the role playing situations at this time. The third, as well as additional situations which you and the students create, can be discussed whenever you feel it is appropriate. It is most important to lead discussions regarding problems encountered when students teach their parents throughout the entire presentation of the curriculum.

3. Please give "instruction sheets" to the children who will be involved in the role playing situations before the class so they will have time to prepare.

4. Please explain that all of the worksheets include "Teaching notes to 5th and 6th graders." These notes should be ignored by children who are not working with parents on this project. They are intended to be used when children take <u>home</u> a copy of this worksheet.

INTRODUCTION AND LINEAR MEASUREMENT - UNIT 1

Lesson 1

Instruction slips for role playing situations (May be cut apart)

Situation A

You are a parent learning the metric system. You read question #3 on your sheet aloud and then say, "I don't know what to do."

Situation A

You are a 5th or 6th grader teaching the metric system. After you see that your parent has a problem with the question, you ask for the necessary materials (book, meter stick, etc.), do the measuring yourself and write the answer on the sheet.

Situation B

You are a parent learning the metric system. You measure the door (question 4 on worksheet) and then say, "I measured it. The door is 2 centimeters and 9 meters high."

Situation B

You are a 5th or 6th grader teaching the metric system. After your parent measures the door you say, "Good, let's write that down."

Situation C

You are a 5th or 6th grader teaching the metric system. You carefully show your parents the meter ruler you have made and demonstrate the lengths of meters and centimeters. You show your parent that there are 100 centimeters in a meter.

Situation C

You are a parent. You listen to your son or daughter's explanation of meters and centimeters. You then study question number 7 on your worksheet but write in an incorrect answer.

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LINEAR MEASUREMENT - UNIT 1

Lesson 1

WORKSHEET

Name or ID Code ______________

Teaching notes to 5th and 6th graders: Be sure to explain:
1. What is a meter? What is a centimeter? (Show your parent(s) the folding meter stick and explain the units it is used to measure)
2. What are the symbols for meter and centimeter?

---

1. Measure this line to the nearest centimeter.

____

2. The length of the room you are now in is _____ meters, _____ centimeters.

3. The measurements of a book (your math book if possible) are:
   length _______ centimeters
   width _______ centimeters
   Did you measure your math book? _____

4. The height of a door in this room is
   _______ meters _______ centimeters

5. My height is approximately _______ meters _______ centimeters.

6. A centimeter is (bigger, smaller) than an inch.

7. There are _______ centimeters in a meter.

8. The symbols for centimeter and meter are
   _______ and _______.

9. A length which measures approximately 1 centimeter is _____________.
   (idea: the width of your little finger?)

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LINEAR MEASUREMENT - UNIT 1

Lesson 2

Objectives

The student will acquire an understanding of the most important events associated with the history of the metric system.

The student will know the terms decimeter and millimeter. He/She will have a concept of the length of each, their symbols, their relationship to other linear terms and be able to use them for measuring.

Materials

Popsicle sticks (1 per child)
Pen, ruler
"The Metric System Day to Day" booklet (1 per student)

Activities

1. Spend a few minutes discussing any difficulties the students had in working with their parents. You may want to have the class "brainstorm" teaching techniques to try in various situations.

2. Use the booklet "The Metric System Day to Day" and your sheet "The Erratic History of Metrics" to give a brief overview of the history of the metric system. Mention that the U.S. is the only industrial country that does not have a firm commitment to the metric system.

3. Introduce the terms and symbols for decimeter and millimeter.

4. Distribute materials and post directions so children can construct decimeter rulers, and complete worksheets. Ask children to mark the distance between 1 and 3 centimeters in millimeters by using a ruler as a guide. (The entire ruler should be marked in centimeters, as well.)

Note to the Teacher

Please distribute the booklet, "The Metric System Day to Day" and ask children to take it home for their parents. Emphasize that their parents may wish to refer to this for the next few weeks so it should be kept in a safe place!

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LINEAR MEASUREMENT - UNIT 1

Lesson 2

WORKSHEET

Name or ID Code ______

Teaching notes for 5th and 6th graders: Be sure to explain:

1. What is a decimeter? What is a millimeter? (Show your parent(s) the decimeter ruler and explain the units it is used to measure)

2. What are the symbols for decimeter and millimeter?

3. How many decimeters are in a meter? How many millimeters in a meter?

---

1. Name something that is approximately the length of
   1 mm ____________ 1 dm ____________

2. There are ______ mm in one m.

3. There are ______ cm in one dm.

4. Choose a table or desk. Using your decimeter stick, measure it to the nearest decimeter. ______ Measure it to the nearest centimeter ______

5. Find things that measure about:
   a) 5 centimeters ____________
   b) 300 centimeters ____________
   c) More than two meters, but less than three meters ______

6. Measure yourself:
   a) Length of nose ____________
   b) Foot ____________
   c) Knees to ankle ____________
   d) Hand span ____________

7. What percent of the world's population is now using, or converting to, the metric system? ______

LINEAR MEASUREMENT - UNIT 1

Lesson 3

Objectives

The student will understand the concept of a decimalized system.

The student will be able to measure and record length using decimal notation.

When given a measurement expressed in meters and centimeters, or meters and millimeters, the student will be able to combine the terms into <u>either</u> meters <u>or</u> centimeters, <u>or</u> millimeters.

When given a measurement expressed in centimeters and millimeters, the student will be able to combine the terms into <u>either</u> centimeters <u>or</u> millimeters.

The student will be able to rename a given linear expression using different units of measure.

Materials

Ditto sheets (1 per child)
Metric rulers

Activities

1. Arrange ten decimeter rulers on a meter stick to demonstrate the relationship between the two units of measure.

2. Review the four metric measurements discussed so far (meter, decimeter, centimeter, millimeter). Make sure students have a good concept of the length of each and their symbols.

3. Discuss methods of combining units using decimal notation. Make sure students understand that:

1 m 49 cm = 149 cm = 1.49 m
1 m 2 mm = 1002 mm = 1.002 m
3 cm 5 mm = 35 mm = 3.5 cm

This may, of course, be related to "place value":

1.527 meters = 1 meter 5 decimeters 2 centimeters 7 millimeters.

4. Give children a variety of examples which require renaming expressions using one unit to expressions using another unit.

examples: 35 meters is also equal to _______ cm
4 centimeters is also equal to _______ mm
6 meters is also equal to _______ dm
760 centimeters is also equal to _______ dm

5. Make sure children understand that the units discussed are all multiples of 10. It is possible, therefore, to change from a larger unit to a smaller unit by multiplying by 10 (i.e. moving the decimal point to the right). It is possible to change from a smaller unit to a larger one by dividing by 10 (i.e. moving the decimal point to the left).

6. Provide examples of line segments for children to measure and ask for answers using decimal notation.

Note to the Teacher

Many children will require additional practice renaming expressions and combining different metric units. Please utilize additional worksheets, games, drills, etc., as you deem appropriate. It may be necessary to extend this lesson over several days to insure that children have mastered the basic skills and concepts that are presented here. This lesson presents the basic concepts of the metric system as a decimalized system. It is vital that the students master this material before proceeding further.

LINEAR MEASUREMENT - UNIT 1

Lesson 3

WORKSHEET

Name or ID Code _______

Teaching notes to 5th and 6th graders: Use your folding meter and decimeter sticks to explain some different ways of writing and combining units.
Examples:

1. 1 meter 12 centimeters = 1 m 12 cm = 1.12 m = 112 cm
2. 2 centimeters 3 millimeters = 2 cm 3 mm = 2.3 cm = 23 mm
3. 4 meters 5 centimeters = 4 m 5 cm = 4.05 m = 405 cm

What do we mean when we say that the metric system is a decimalized system?

____

1. If a line measured 5 centimeters and 6 millimeters, we could also say that this line was _______ mm long. Or we could say that the line was _______ cm long.

2. 6 meters 25 centimeters = _______ cm or _______ m.

1) Circle the larger measurement in each pair

a)	500 mm	6 m
b)	25 mm	32 cm
c)	4.3 cm	61 mm

3. 2 cm 8 mm = _____ cm or _____ mm

4. 6 meters 5 centimeters = _____ m or _____ cm

5. 800 mm = _____ m or _____ cm

6. Measure this line segment. Give your answer using centimeters only.

answer _____________

7. My height is _______ meters _______ centimeters. This is the same as saying that I am _______ centimeters tall or that I am _______ meters tall.

(Example: My height is 1 meter 65 centimeters. This is the same as saying that I am 165 centimeters tall or that I am 1.65 meters tall.)

LINEAR MEASUREMENT - UNIT 1

Lesson 4

Objectives

The student will know the terms dekameter, hectometer and kilometer and their values in relationship to the meter. He will be able to rename kilometers to meters.

The student will know the symbol for kilometer and have an idea of its length.

The student will be able to identify the appropriate unit of measure to use in a given situation.

The student will be able to measure the perimeter of plane figures.

Materials

Ditto sheets (1 per student)

Activities

1. Introduce the terms dekameter, hectometer and kilometer, emphasizing that only kilometer is commonly used. Review the concept of a decimalized system, now including these new units. Mention that a kilometer equals .6/10 of a mile and identify a distance which is approximately one kilometer.

2. Give examples of changing from kilometers to meters, emphasizing the need to have an answer that is a larger number (because it is expressed using a smaller unit) than in the given problem.

Example: 5 kilometers = 5000 meters

3. Present a chart of all the prefixes:

Prefix	Factor
kilo	1000 (one thousand)
hecto	100 (one hundred)
deka	10 (th)
meter	1
deci	.1 (one tenth)
centi	.01 (one hundredth)
milli	.001 (one thousandth)

Discuss the chart and allow the children to practice changing from one unit to another.

4. Have children question the group regarding the most appropriate unit to use to measure a given distance. (Example: What unit would you use to measure the distance from Baltimore to New York? The length of your pencil? The width of a dollar bill?)

5. Review the method of computing the perimeter of a given plane figure. If this topic is difficult for your students, provide additional problems for discussion.

6. Distribute worksheets.

Note to the Teacher

1. If appropriate for your class, you may include the following objectives in this lesson:

a) The student will measure the radius, diameter and circumference of a circle.

b) The student will compute the circumference of a circle.

LINEAR MEASUREMENT - UNIT 1

Lesson 4

WORKSHEET

Name or ID Code _______

Teaching notes to 5th and 6th graders: Be sure to explain:

1. The terms dekameter, hectometer and kilometer (remember, only kilometers are commonly used) and their symbols.
2. Page 5 of "The Metric System Day to Day."
3. The method for finding a perimeter.

---

1. One meter = _____ decimeters = _____ centimeters = _____ millimeters = _____ kilometers

Complete this Table:

kilometer	hectometer	dekameter	METER	decimeter	centimeter	millimeter
	4.95hm	49.5dam	495m	4950dm		495 000mm
0.052km	0.52hm	5.2dam	52m		5200cm	
	0.03hm	0.3dam	3m	30dm	300cm	
0.000872 km	0.00872hm	0.0872dam			87.2cm	872mm

6. A distance that is approximately 1 kilometer is ____. (example: from the front door of school to the corner of Maple and Elm Streets. You may want to "clock" this in the car, when you have a chance)

7. A speed of 50 miles per hour is most similar to:
   a) 80 kilometers per hour b) 20 kilometers per hour
   c) 50 kilometers per hour d) 120 kilometers per hour

8. A triangle has sides of the following lengths:
   3 m 84 cm, 1 m 16 cm, 3 m 84 cm,
   Find the perimeter. Express your answer in the simplest terms possible. ____

9. Choose the appropriate unit (millimeter, centimeter, meter, kilometer) to measure the following distances:

a) The height of a 10 year old child _______
b) The width of a roll of film _______
c) The distance from New York to Philadelphia _______

LINEAR MEASUREMENT - UNIT 1

Lesson 5

Objectives

The student will be able to solve appropriate word problems requiring knowledge of metric linear terms.

Materials

Worksheets - 1 per child

Activities

1. Provide an opportunity for the children to practice adding, subtracting, multiplying and dividing with metric quantities.

2. Review the method for computing the perimeter of a given plane figure. Present practical situations which would require the computation of a perimeter. Distribute worksheets.

Note to the Teacher

You will probably wish to provide additional work problems designed to meet the specific needs of your students.

LINEAR MEASUREMENT - UNIT 1

Lesson 5

WORKSHEET

Name or ID Code ________

1. Find the perimeter of a dollar bill. ________
Or, find the perimeter of your math book. ________

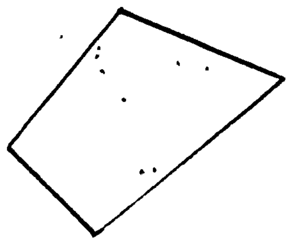
2. John measured the distance from Los Angeles to New York on a map. He found it to be 19.2 cm. If the map has a scale of 1 cm for 200 km, what is the distance from Los Angeles to New York? ________

3. If plywood paneling is 120 cm wide, how many panels will be needed to cover a wall that is 9 meters wide? ________

4. Betty wants to build a small shelf in her closet. She bought a board 1 meter long. Since her closet is only 80 centimeters across, how much must she cut off the board? ________

5. Carol's mother is sewing a costume for her to wear. She measures a length of ribbon and discovers that it is 3.2 meters long. Carol finds a piece that is 649 centimeters long. What is the combined length of the two pieces of ribbon they now have? ________

6. Measure the sides and find the perimeter of this figure. Use decimal notation to combine cm and mm.



AREA - UNIT 2

Lesson 1

Objectives

The student will know that the area is the number of square units inside a two-dimensional figure.

The student will know that the area of a rectangle can be found by multiplying its length times its width.

The student will know the term square centimeter, its symbol and have an idea of the size of the unit.

The student will know that the exponent in the symbols for metric units of area means "square."

Materials

Worksheets - 1 per child

Activities

1. Review the concept of area with the children. Demonstrate the derivation of the formula for finding the area of a rectangle by using a centimeter grid (or diagram of one on the board).

2. Introduce the term square centimeter, and its symbol. List objects whose surfaces could appropriately be measured in square centimeters.

Note to the Teacher

If you think it is appropriate for your class, you may include the following objectives with this lesson:

- The student will be able to compute the area of a triangle
- The student will be able to compute the area of a quadralateral (trapezoid, parallelogram)

AREA - UNIT 2

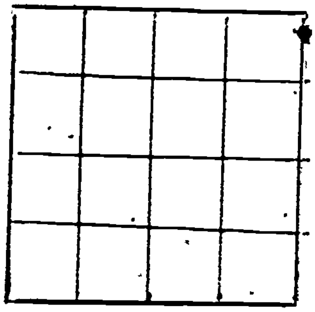
Lesson 1

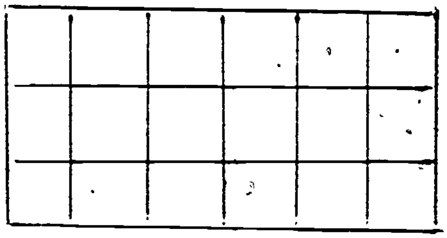
WORKSHEET

Name or ID Code ________

Teaching notes for 5th and 6 graders: Be sure to explain:

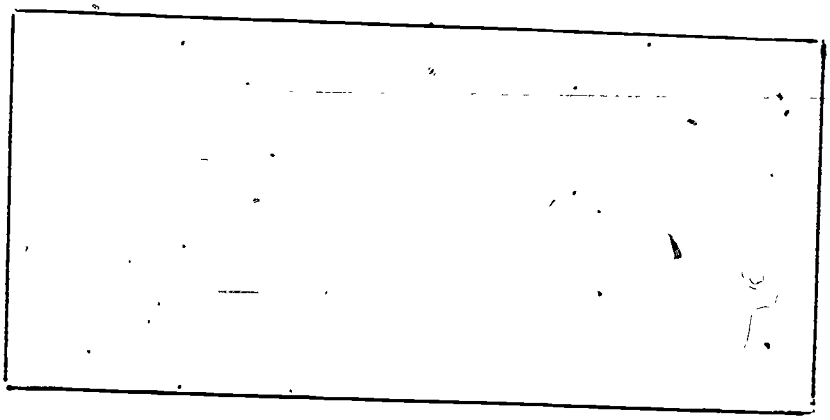
1. The meaning of "area."
2. The formula for finding the area of a rectangle.
3. The term "square centimeter" and its symbol.





1. This square has an area of: ________

2. This rectangle has an area of ________



3. Use your ruler to measure the length and width of this rectangle. Then find the area.

AREA - UNIT 2

WORKSHEET (Cont'd)

4. Find the area of rectangles with the following dimensions:

a) length 1.8 cm
   width 9 cm   Area = ______

b) length 7.2 cm
   width 8 cm   Area = ______

5. A square centimeter is (larger than, smaller than) a square inch.

AREA - UNIT 2

Lesson 2

Objectives

The student will draw a rectangle with a given area on a centimeter grid.

The student will know the term square meter, its symbol, and have a concept of its size and relationship to a square centimeter.

Materials

Worksheets - 1 per student
Centimeter graph paper - 1 sheet per student
Newspaper or colored construction paper, tape
Rulers, scissors
Meter sticks (see "Notes to the Teacher")

Activities

1. Distribute centimeter graph paper and ask students to use the top portion of this paper to draw figures that have an area of 42 cm (Each child is to draw one figure.) Encourage them to exchange papers in order to appreciate the number of figures that can be drawn with the same area.

2. Ask children to trace their hands on the lower portion of the sheet and count centimeter squares and "half squares" (or portions of squares) to approximate the area covered by their hands.

3. Introduce the term square meter. Discuss its symbol and relationship to the square centimeter. Distribute newspaper or construction paper, rulers, tape and scissors. Have the children work in groups to construct pieces of paper that are equivalent to one square meter. Discuss areas that would be measured using the square meter.

4. Distribute worksheets and ask children to complete them.

Note to the Teacher

1. You may want to have several children construct a few models (templates) of square meters before the lesson to be used later by the class. This would eliminate the need for a large supply of meter sticks.

2. You will want to save the square meters, if constructed of colored paper, for use in the next unit.

3. If you feel it is appropriate, you may wish to include these objectives with this lesson:

- The student will compute the area of a circle
- The student will compute the surface area of a right prism
- The student will compute the surface area of a right circular cylinder.

AREA - UNIT 2

Lesson 2

WORKSHEET

Name or ID Code ________

Teaching notes to 5th and 6th graders: Be sure to explain:

1. The meaning and symbol of a square meter. (You may either use your folding meter stick and newspaper to construct a square meter at home or show your parent(s) the one you made in school).

2. How to determine the measurement of a particular space in square meters.

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1. Each side of 1 square meter is _______ cm long.

2. There are _______ square centimeters in a square meter.

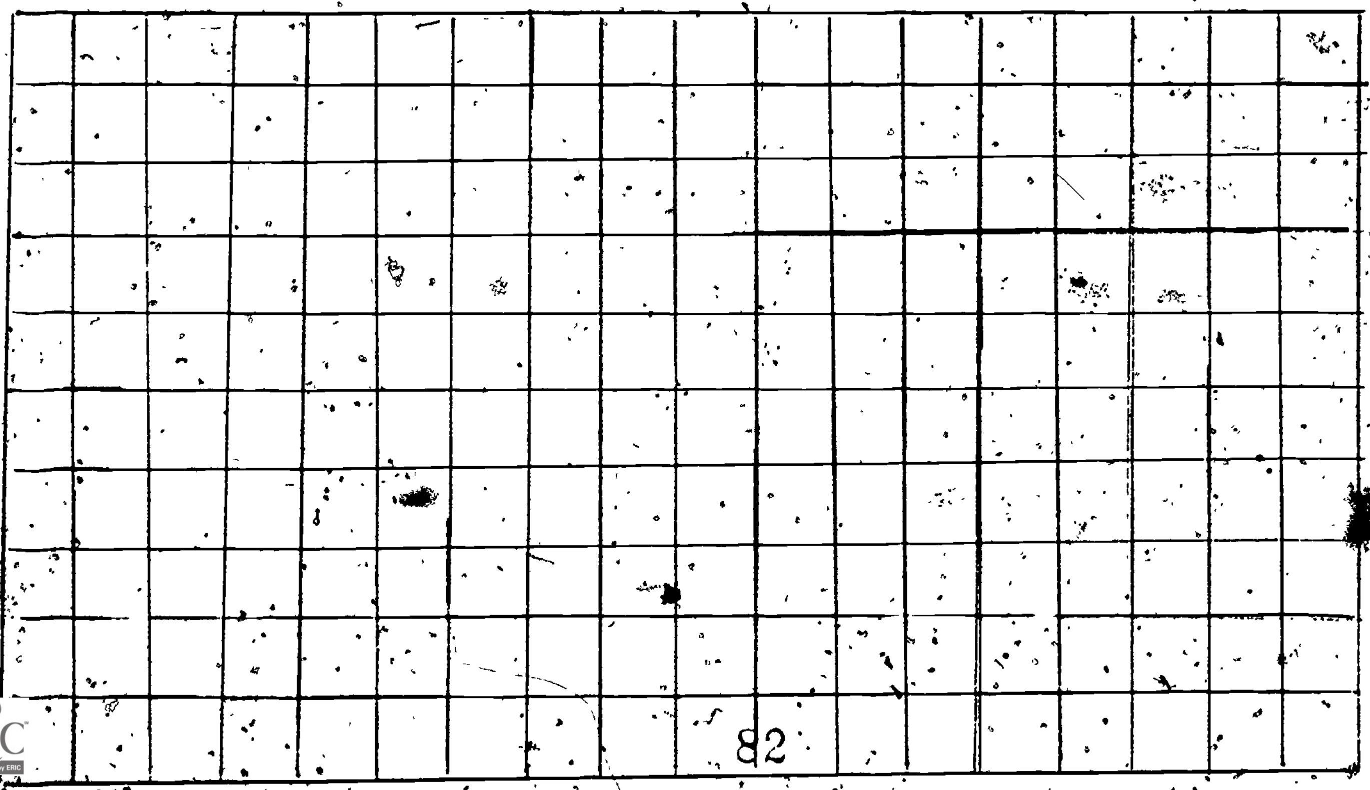
3. If a large classroom measured 12 meters wide and 16 meters wide, the area of the ceiling would be _______.

4. A square is 3 meters long on each side. Its area is _________.

5. The symbol for square meter is _______.

6. On the centimeter graph below, draw three figures with different shapes. All three figures must have the same area.

7. Name three areas that would appropriately be measured, using square meters. __________________, __________________, __________________



AREA - UNIT 2

Lesson 3

Objectives

The student will know the terms square millimeter, hectare, and square kilometer. He/She will know their symbols, have a concept of the size of each and be aware of measurements for which they may appropriately be used.

The student will understand that the term square millimeter is not commonly used in every day life.

The student will be able to identify the area measurement that is most appropriate for a given situation.

Materials

Worksheets - 1 per child

Activities

1. Introduce the term square millimeter, emphasizing that it is used primarily in science. Ask the children to draw a square millimeter, and write its symbol.

2. Briefly discuss the terms hectare and square kilometer. The following information should be included in your discussion:

a) A hectare is approximately the size of a baseball field or 2 football fields placed side by side. It is about 2.5 times the size of an acre and will replace the acre as a measure of land. A hectare is a square that is 100 meters on each side. Emphasize that hectare (ha) does not have an exponent.

b) A square kilometer is 1 km (1000 meters) on each side. It is approximately the area of 200 football fields. (A football field is about 100 meters long, from goal post to goal post, and about 50 meters wide.) Large land areas (ex. states) or oceans can be appropriately measured in square kilometers.

3. Have a few children measure and compute the area of the classroom using square meters.

4. Write all of the units of area measurement that have been discussed on the board. Ask the children to list several uses for each unit.

AREA - UNIT 2

Lesson 3

WORKSHEET

Name or ID Code ________

Teaching notes for 5th and 6th graders: Be sure to explain:

1. The terms millimeter, hectare, kilometer. (Which will replace the acre?)

2. One use for each term

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1. A hectare is about _______ times the size of an acre.
   a) 2.5 b) 5 c) 8 d) 10

2. A square kilometer measures _______ meters on each side.

3. Select a proper metric unit for measuring each of the following. You may choose from mm^2, cm^2, m^2, hectare and km^2 (There may be more than one correct answer.)

   a) a national forest _______
   b) a basketball court _______
   c) the size of Colorado _______
   d) a cornfield _______
   e) the field of view under a microscope _______
   f) the size of Lake Erie _______
   g) a postage stamp _______
   h) a living room floor _______

AREA - UNIT 2

Lesson 4

Objectives

The student will be able to solve appropriate word problems requiring knowledge of metric terms.

Materials

Worksheets - 1 per child

Activities

1. Review the necessity of expressing measurements in the same unit before beginning computations. Make certain children remember how to convert from centimeters to millimeters and millimeters to centimeters.

2. Provide a few examples of problems which require multiplication and division of metric area units to give children practice.

3. Distribute worksheets.

Note to the Teacher?

You may wish to have your students measure given areas outside the school building -- (play areas, parking lots, a planted garden) to help them acquire a better sense of the size of a square meter

AREA - UNIT 2

Lesson 4

WORKSHEET

Name or ID Code ________

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1. If you had a piece of land that measured 60 m X 40 m, its area would be ______.

2. A man fenced in a square plot of ground. Each post was exactly 2 meters apart. When he had finished, he had 12 fence posts on each side of his square. What was the area of his square? ________

3. A square tile has an area of 64 square centimeters. What is the length of each side of the square? ________

4. 6 cm X 8 cm = 48 ______

5. A trampoline is 4 meters long and 2 meters wide. Find its area. ________

6. 6 mm X 8 mm = 48 ______

7. Find the area of a rectangle with these dimensions:

   length 5.7 cm
   width 9 mm   Area ______

8. Estimate the following areas. Then use your centimeter ruler or folding meter ruler and decimeter ruler to measure the dimensions. Compute and record the areas.

object	estimated area	measured area
refrigerator door		
magazine cover		

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VOLUME AND CAPACITY - UNIT 3

Lesson 1

Objectives

Students will review basic concepts related to volume: (1) Volume is the amount of space occupied by a solid, liquid or gas, (2) The volume of a rectangular prism may be found by multiplying the length times the width times the height, (3) Objects with different shapes can have the same volume.

Students will know the terms cubic centimeter and cubic decimeter and their symbols. They will have an idea of the size of each unit and their relationship to each other.

Materials

1 index card per child, cm ruler, tape, scissors
4 ditto sheets per child to use in constructing decimeter cube.
(2 sheets each of sheets A and B)

Activities

1. Discuss basic concepts of volume (see above) with class.

2. Have the class use index cards marked with configuration to construct a 1 cm^3 cube.

3. Read instructions and have the children each use ditto sheets to construct a one decimeter cube.

4. Through discussion, lead ~~children~~ to the following conclusions:

a) The decimeter cube which they constructed has a volume of 10 cm X 10 cm X 10 cm = 1000 cm^3

b) There are 1000 cm^3 in one dm^3

c) 1 dm^3 may also be said to have a volume of 1 dm X 1 dm X 1 dm.

5. Emphasize the correct methods of writing the terms "cubic centimeter" and "cubic decimeter" and their symbols.

Notes to the Teacher

1. This unit assumes that students are familiar with the definition of volume and the formula for finding volume of a rectangular prism and that they know that objects of different shapes can have the same volume.

2. Children may be asked to draw the configuration for the cubic centimeter themselves, or you may decide to have a small group of children measure and draw the configurations on all of the index cards before the lesson. In the latter case, you would, of course, have the children measure to discover the dimensions of the cube before constructing it.

3. You may choose to have the children construct their decimeter cubes in groups (making enough copies of the directions for each group) or to have the class work together and follow the directions individually as you read them. In either case, be sure they examine and understand that each side of the cube is a square decimeter.

4. Please ask children to keep the materials they have made in school to use during the next lesson. <u>(There is no worksheet or work for parents with this lesson.)</u>

5. Please construct (or ask a child to construct) a decimeter cube from cardboard for use in measuring liquids in lesson #3. It does not need to be marked in centimeter squares. You should also keep a cardboard centimeter cube for measuring liquids in lesson #3.

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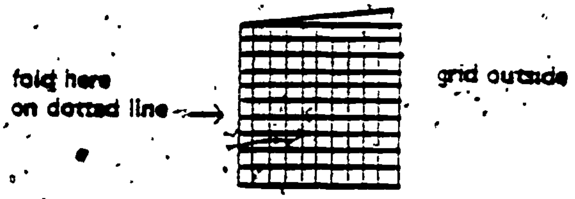
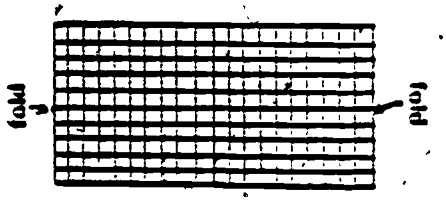
Directions for constructing a one decimeter cube*

How to make the sides of the cube:

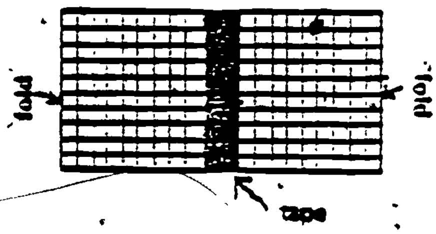
1. Cut out the two rectangles on the sheets marked A. Cut along the solid bold lines.
2. Fold each rectangle in half by folding along the dotted line. Fold the rectangles so that the cm grid is on the outside.



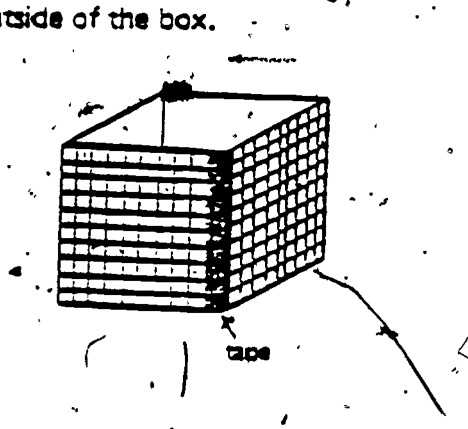
3. Lay the folded rectangles on a flat surface so that the open sides (opposite the folds) line up and touch right up against each other.



4. Tape the two sides together like this:

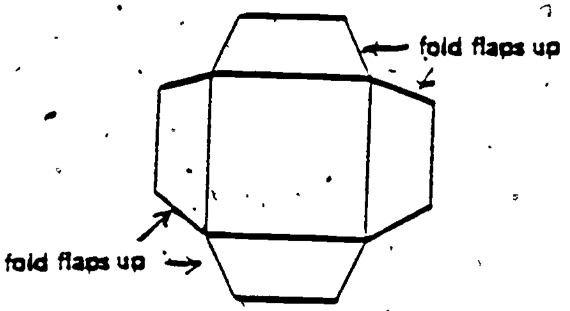


5. Keep the piece folded and turn the whole piece over. Now tape the other two sides together in the same way.
6. Pick up the whole piece and shape it into a box without a top or bottom. The grid should be on the outside of the box.

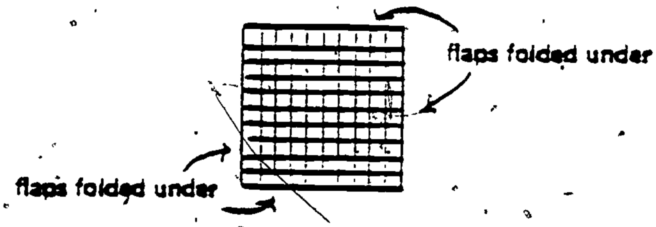


How to make the bottom and top of the cube:

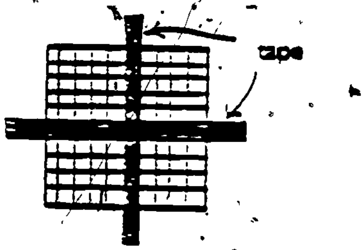
7. Cut out the two pieces on the sheets marked B. Cut along the solid bold lines.
8. Take one of the pieces and lay it on a flat surface with the cm grid face down. Fold all four flaps up by folding along the dotted lines.



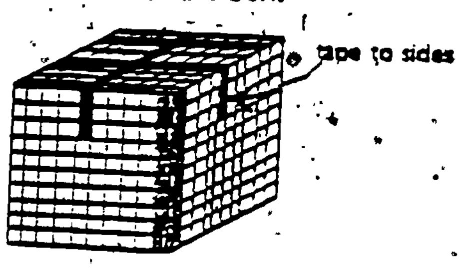
9. Turn the piece over so the grid is face up. Keep the flaps folded under. The piece shoulc look like this:



10. Put the two pieces of tape across the square. Leave some tape hanging over each side.

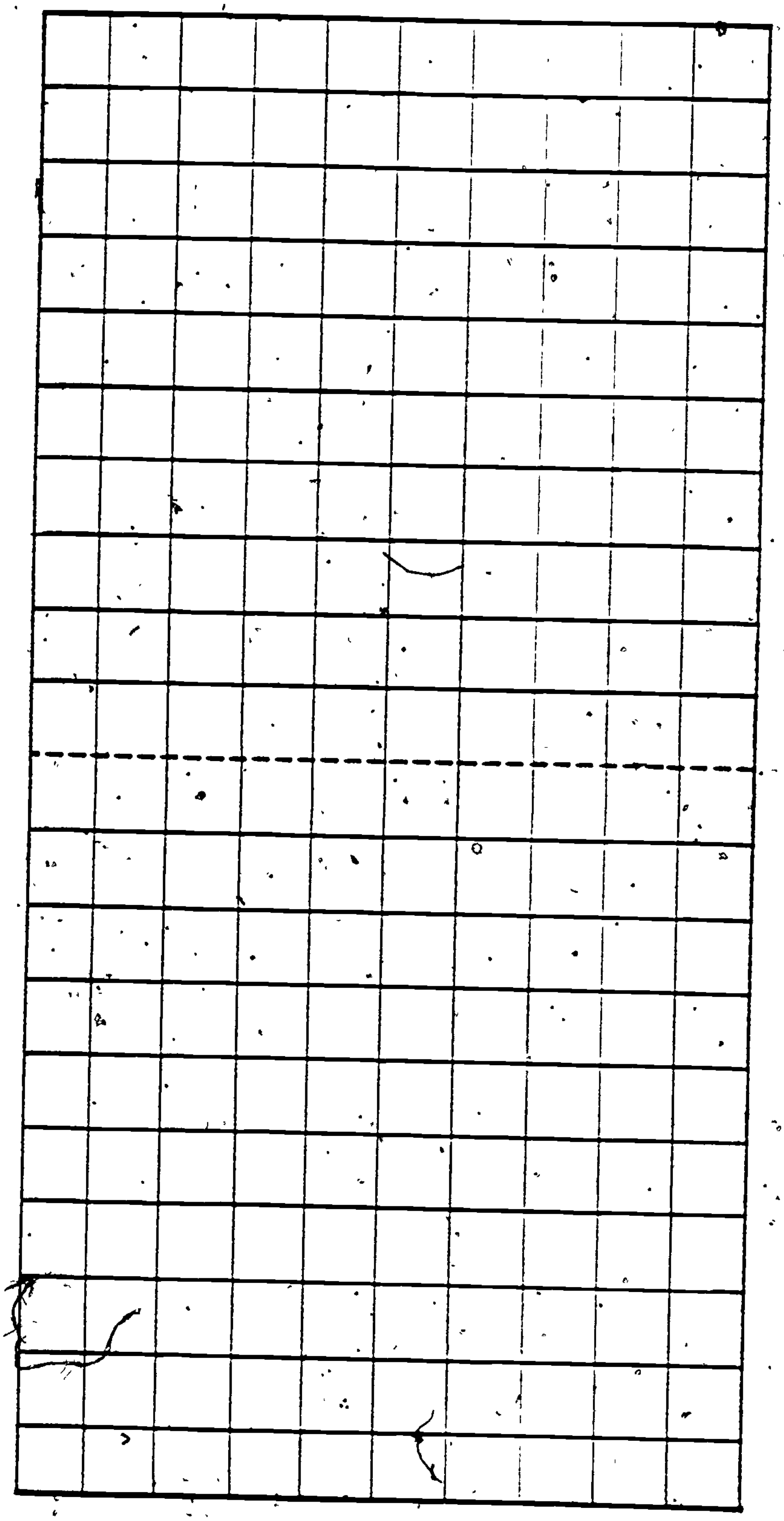


11. Pick up the square by holding the ends of one of the pieces of tape and place it on top of the open box. When you do this, the open box should be standing on a flat surface. The flaps of the square go inside the box. Secure the square to the box by sticking the ends of the tape onto the sides of the box.



12. Turn the box over and make the top of your cube in the same way (follow steps 7-12).

SHEET A — RECTANGLE FOR MAKING SIDES OF CUBE*



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VOLUME AND CAPACITY - UNIT 3

Lesson 2

Objectives

The student will know the term cubic meter and its symbol, and will have an idea of its size and relationship to a cubic centimeter and cubic decimeter. He/She will be able to change an expression using one unit to an equivalent expression using different units.

The student will be able to identify the correct unit of volume to use when measuring a given space.

The student will be able to estimate and then verify the volume of given rectangular prisms. He/She will be able to measure and record volume by counting cubic units.

Materials

12 meter sticks (per class)
Previously constructed decimeter and centimeter cubes - 1 per child
Worksheets - 1 per child
Previously constructed square meters (If made with construction paper)
Tape

Activities

1. Ask several children to hold the meter sticks together to demonstrate the size of a cubic meter. If you wish, you may temporarily tape all the sticks together.

2. Demonstrate and discuss the relationships between cm^3, dm^3 and m^3. Make sure students understand that:

$$1\ cm \times 1\ cm \times 1\ cm = 1\ cm^3$$
$$1\ dm \times 1\ dm \times 1\ dm = 1\ dm^3 \qquad 1000\ cm^3 = 1\ dm^3$$
$$1\ m \times 1\ m \times 1\ m = 1\ m^3 \qquad 1000\ dm^3 = 1\ m^3$$

3. Spend some time having children measure and compute the volume of given spaces in the classroom, (example, a closet, desk drawer, shoe box) before they begin working on this worksheet.

Notes to the Teacher

1. If several classes are to be constructing cubic meters at the same time, you may wish to have one class actually tape the meter sticks together and exhibit the cube to the other classes.

2. If students constructed their square meters (described in the previous unit) from colored paper, have them work in groups to tape them together and construct cubic meters. They will need to use a carton or other large object to prop up the pieces, or attach one side to a wall.

3. Ask children to bring home their cubic centimeters and cubic decimeters.

4. If you think it is appropriate for your class, you may include the following objective with this lesson:

The student will be able to compute the volume of a right circular cylinder.

VOLUME AND CAPACITY - UNIT 3

Lesson 2

WORKSHEET

Name or ID Code ________

Teaching notes to 5th and 6th graders: Use your cubic centimeter and cubic decimeter. Be sure to explain:

1. How many cm^3 are in a dm^3?
2. How many dm^3 are in a m^3 (Describe the way we made a m^3 in class)
3. How to find the volume of a rectangular prism (multiply length times width times height)

---

1. Name the unit (cm^3 or dm^3 or m^3) used to measure the volume of the following. Guess the volume and then measure (use meter and decimeter sticks) to see how good your guess is. When measuring length, width and height, measure to the nearest whole unit.

Thing	Unit	Guessed Volume	Measured Volume (approx.)
1. Closet			
2. Tissue box (or other small box)			
3. Drawer			

4. Find the volume of a box having a length of 8 cm, a width of 4 cm and a height of 5 cm. ________

5. Name two things in your house that have volumes of approximately one cubic meter. ________, ________

6. Which unit would you use to measure the volume of dirt to be hauled away to build a basement?

a) m^3 b) dm^3 c) cm^3 d) mm^3

7. Use your cubic centimeter to measure the volume of a small box. Then use your decimeter ruler to find the length, width, height and then volume of the box. Compare your two figures.

volume (using centimeter cubes) ________
volume (using volume formula) ________

VOLUME AND CAPACITY - UNIT 3

Lesson 3

Objectives

The student will know the terms liter and milliliter, their symbols, relationships to each other and will have a good concept of the size of each.

The student will know that the liter is the basic unit of measure for liquid in the metric system.

The student will know that 1 cubic centimeter is equivalent to 1 milliliter and that 1 cubic decimeter is equivalent to 1 liter.

Materials

½ gallon milk cartons - 1 per child
Permanent, felt-tip markers (a few)
Several liter containers (example - coke bottle) to demonstrate size of liters
Ditto sheets - 1 per child - giving directions for making liter containers
Decimeter and centimeter cubes constructed in previous lesson (for demonstration)
1 decimeter cube made of cardboard
mL medicine droppers (a few per class)
Masking tape

Activities

1. Show children the liter containers. Emphasize that the liter is the basic unit of measure for liquids in the metric system. Almost all liquids are measured in liters. Discuss common uses of liters (to measure milk, gasoline, oil, etc.)

2. Work with children, as a class or in small groups, to construct liter containers, using milk cartons. Have the children use any accurate liter containers to test the ones they have made.

3. Use the cardboard decimeter cube to demonstrate to the class that 1 cubic decimeter is equal to 1 liter. (Pour water from one into another to show that they hold the same amount.) Use milliliter medicine droppers to demonstrate that 1 cm^3 has a capacity of 1 mL. (Pour water from a centimeter cube into a mL eyedropper.) Make sure children understand that:

$$1 \text{ mL} = 1 \text{ cm}^3, \; 1000 \text{ mL} = 1 \text{ L}$$

There are, therefore, 1000 cm^3 in a liter. Be sure to teach the correct symbols, and the relationship between a mL and L.

4. Divide the class into groups to complete worksheets.

Notes to the Teacher

1. You may wish to explain to the children that although liters and cubic decimeters are equivalent, the liter is used to measure liquids and is a measure of capacity. The cubic decimeter (and cubic centimeter) is a measure of volume, derived from linear units, and is usually used to measure solids.

2. Although question #8 on the worksheet is to be done "at home only," you may want to ask a few children to demonstrate measuring techniques with their liter containers using this procedure.

3.

Notes to the Teacher

1. You may wish to explain to the children that although liters and cubic decimeters are equivalent, the liter is used to measure liquids and is a measure of capacity. The cubic decimeter (and cubic centimeter) is a measure of volume, derived from linear units, and is usually used to measure solids.

2. Although question #8 on the worksheet is to be done "at home only," you may want to ask a few children to demonstrate measuring techniques with their liter containers using this procedure.

3.

Directions for Construction of Liter Containers

(Lesson 3)

1. Undo the top of a half-gallon milk carton so that it is completely open.

2. On the outside of the carton, measure 12 cm up from the bottom along one of the corners. Make a mark on the corner at that point.

3. Mark the other three corners in the same way.

4. Cut each corner down from the top of the carton, stopping at the 12 cm mark you made.

5. Fold each top flap over and back a few times to form a crease around the carton.

6. Cut the top flaps off by cutting around the carton on the creases.

7. Using a permanent, felt-tip marker and a cm ruler, measure up 5 and 10 cm from the bottom, inside the carton, and make a mark at each point. Repeat this step on one or two more sides.

8. You now have a container that holds slightly more than a liter, but the marks inside the carton are a very close approximation of 1 liter and .5 liter. Label these marks "1 L" and ".5 L."

VOLUME AND CAPACITY - UNIT 3

Lesson 3

WORKSHEET

Name or ID Code ________

Teaching notes to 5th and 6th graders: Be sure to demonstrate and/or explain:

1. The sizes of liter and milliliter containers
2. The number of milliliters in a liter
3. The relationships between milliliters and cubic centimeters and liters and cubic decimeters

---

1. Liters may be used to measure _______.

   a) the amount of medicine you should take
   b) the amount of water in a pool
   c) the amount of oil you put in your car
   d) the amount of sand in a truckload

2. The symbol for milliliter is

   a) ml b) mL c) mL. d) ml.

3. There are _______ milliliters in one liter.

   a) 10 b) 100 c) 1000 d) 10000

4. Use your milliliter eyedropper (the same as 1 cubic centimeter) to determine the number of milliliters in a teaspoon and a tablespoon (use measuring spoons if possible)

   There are _______ milliliters in a teaspoon.
   There are _______ milliliters in a tablespoon.

5. In the metric system, a one centimeter cube will hold 1 milliliter of water. A 50 cubic centimeter container should hold _____ milliliters of water.

   a) 50 b) 500 c) 0.5 d) 100

6. In the metric system, a one decimeter cube will hold 1 liter of water. A container having a volume of 3 cubic decimeters should hold _____ milliliters of water.

   a) 3 b) 300 c) 3000 d) 0.3

WORKSHEET (Cont'd)

7. Indicate the unit (cubic centimeters or milliliters) that would be used to measure each of the following:

a) The size of a box of staples ______
b) The contents of a bottle of medicine ______
c) The contents of a bottle of food coloring ______

8. (To do at home only): Pour some water into three different "small pot-sized" containers. Estimate the amount of water in each container. Then use your milk carton-liter container to measure the water.

	Estimated Amount	Measured Amount (approx)
Water in Container #1		
Water in Container #2		
Water in Container #3		

VOLUME AND CAPACITY - UNIT 3

Lesson 4

Objectives

When given a measurement in mL and L, the student will be able to express the measurement in either milliliters or liters.

Materials

16 ounce clear plastic cups
Waterproof marking pen
Masking tape
Milk carton - 1 per child
Metric ruler - 1 per child
Scissors
Milliliter measuring cup
Ditto sheets of instructions - 2 per child
Worksheets - 1 per child
Small paper cups (dispenser size) - marked to indicate 100 mL
Water (optional: colored water is easier to see)

Activities

1. Review the method of renaming unlike linear terms and then focus on the combination of liters and milliliters.

(Example: 1 liter 30 milliliters = 1.03 Liters)

2. Use a milliliter measuring cup to demonstrate measuring techniques. Emphasize that the measuring cup about to be constructed will be used for measuring smaller amounts of liquid with greater accuracy than the milk carton container constructed in lesson #3.

3. Demonstrate the use of the displacement bucket, noting that it is important to fill the bucket to the overflow and measure the water that is displaced very carefully. This device is not very accurate, but is included to give children experience working with the relationship between metric units of volume and capacity.

4. Ask children to follow the directions on the ditto sheets to construct measuring cups and displacement buckets.

Notes to the Teacher

1. You may wish to have the children work in groups, pairs, or individually when working on these constructions.

2. Ask the children to leave their constructions in school to use during the next lesson.

3. Although the worksheet includes one problem which requires the use of the displacement bucket, you may wish to provide other examples.

MILLILITER MEASURING CUP

Materials and Tools

- 16 ounce clear plastic cup
- Masking tape
- Waterproof marking pen
- Small paper cups (dispenser size) marked to indicate 100 mL
- Water (optional: colored water is easier to see)

Procedure

1. Place a strip of tape on the side of the large plastic cup.

2. Transfer the amount of water necessary to reach the 100 mL mark on the small cup into the plastic cup and mark the water level on the tape with a marking pen.

3. Repeat the procedure a few times until you have placed 500 mL of water into the cup (Notice that the marks become closer together as the cup becomes wider).

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VOLUME AND CAPACITY - UNIT 3

Lesson 4

WORKSHEET

Name or ID Code ____________

Teaching notes to 5th and 6th graders: Be sure to explain how to write an expression using both milliliters and liters in an equivalent form using milliliters <u>or</u> liters.

Examples:

1) 2 liters 5 milliliters = 2005 mL <u>or</u> 2.005 L
2) 1 liter 200 milliliters = 1200 mL <u>or</u> 1.200 L which equals 1.2 L
3) 26 liters 35 milliliters = 26 035 mL <u>or</u> 26.035 L

Write the letter of the equivalent measurement from column #2 next to each expression in column #1.

Column #1	Column #2
1. 32 L 865 mL _____	a. 15.003 L
2. 30 liters 5 milliliters _____	b. 4.018 L
3. 15 L 3 mL _____	c. 32865 mL
4. 1 L 1 mL _____	d. 3136 mL
5. 22 liters 58 milliliters _____	e. 22058 mL
6. 3 liters 136 milliliters _____	f. 1.001 L
7. 4 L 18 mL _____	g. 30005 mL
8. 1 liter 100 milliliters _____	h. 1.1 L

9. 8472 mL is equal to:

a) 84.72 L b) 8.472 L c) 0.8472 L d) 847.2 L

10. 2.003 liters is equal to:

a) 20003 mL b) 20.03 mL c) 200.3 mL d) 0.2003 mL

11. 650 mL = ______ L

12. 0.2 L = ________ mL

VOLUME AND CAPACITY - UNIT 3

Lesson 5

Objectives

The student will be able to estimate and verify capacities by measuring given quantities of water with metric measuring materials.

The student will be able to use a displacement bucket to measure the volume of irregularly shaped solids by liquid displacement in a measuring cup.

The student will be able to solve appropriate word problems requiring knowledge of volume and capacity measurement using metric units.

Materials

Previously constructed measuring cups and displacement buckets - 1 per child
Ditto sheet of problems - 1 per child
Rocks - 1 per child
Small containers holding water to be measured (Several students may measure the same amount of water)

Activities

1. Choose one problem from the worksheet which requires use of the displacement bucket, in order to demonstrate its use, and the concept involved. Additional problems requiring measurement may be solved and discussed by the class, as necessary, to ensure that pupils are knowledgeable about measurement techniques.

2. Children use metric measurement materials to solve word problems on a worksheet.

VOLUME AND CAPACITY - UNIT 3

Lesson 5

WORKSHEET

Name or ID Code ___________

Notes to 5th and 6th graders: Be sure to demonstrate and/or explain:
1. How you made your measuring cup and how it is used for measuring liquids. How is its use different from your milk carton liter?
2. How you made your displacement bucket and how it is used for measuring the volume of irregular solids.

---

1. Place a small amount of water in a container such as a jar or bowl. Estimate the amount of water you have. Then pour the water into your measuring cup and record the measurement. Do this several times with differing amounts of water.

Measurement #1: Estimated amount ______ exact amount ______
Measurement #2: Estimated amount ______ exact amount ______
Measurement #3: Estimated amount ______ exact amount ______

2. Fill your displacement bucket with water to the overflow. Place your measuring cup under the overflow. Put a rock (or some other irregular object) into the bucket. The water that is displaced (flows into the cylinder) equals the volume of the rock.

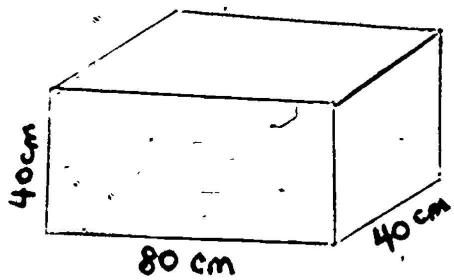
What unit will you use to measure the water that is displaced?
____

How much water is displaced? ________

What unit will you use to describe the volume of the rock?
____

What is the volume of the rock? ________

3. What is the capacity of the aquarium (pictured below) in cm^3?
________, in mL? ________, in L? ________



MASS - UNIT 4

Lesson 1

Objectives

The student will know the term gram, its symbol and approximate weight.

The student will be able to estimate and then verify the weight of given objects, using a spring scale.*

Materials

Three rubber bands (all the same size) or one spring
A small paper cup
2 paper cups
Board or wall with nail or hook in it
Paper
Standard mass pieces
Pencil
Directions for constructing spring scale - 1 per child
Metric scale
For mass pieces:
  Plastic bags with ties - 3 per child
  Rice, sand or salt or clay
Worksheets
Nickels (approximately 30)

Activities

1. Discuss the distinction between mass and weight: Mass is a measure of the amount of matter that there is in an object. Weight is the pull of gravity. The weight of an object may change with location — moon to earth, while the mass remains constant. In commercial and everyday use, the word "weight" nearly always means mass. In these lessons, "determine the mass of" will mean the same as "weigh." The difference between mass and weight has nothing to do with the metric system.

2. Use a metric scale to demonstrate the following:

a paper clip has a mass of approximately 1 gram
a new penny has a mass of approximately 3 grams
a nickel has a mass of approximately 5 grams

3. Divide children into groups or pairs to construct spring scales, complete worksheets, and make their own mass pieces. Children may use clay or fill small plastic bags with sand, salt or rice to make

*Note: The spring scale replaces a coat hanger balance which was included in the original curriculum. The balance proved to be inaccurate and difficult to construct.

mass pieces. Each should be carefully marked. "Homemade" mass pieces are being constructed to give parents, as well as students, a feel for the weights of metric units. Use a scale to varify the accuracy of the weights before sending them home.

Weights made by grouping 5 nickels together (each group will have a mass of approximately 25 grams) may also be used to calibrate the scale.

Notes to the Teacher

1. Please make the following suggestions to students regarding the use of the spring scale:

a) The scale is best used to weigh objects having masses between 25 and 200 grams.

b) The marks indicating weights should be approximately 25 grams apart (i.e. marks might be made for weights of 25 grams, 50 grams, 75 grams, etc., to a maximum of 200 grams).

c) The scale gives an approximation (not an accurate reading) of the weight of a given object.

d) As the rubber bands stretch (with use) the accuracy of the scale diminishes. To prolong the life of the scale, suggest that students remove objects from the cup immediately after they are weighed and remove the scale from the hook when it is not in use. They may wish to bring materials home to make a second scale to use with their parents.

2. If you have an appropriate scale, you may want to have the students weigh objects using kilograms, as well as grams.

3. As a supplemental activity, some children may wish to weigh several quantities of dried beans, keeping a record of their findings.

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MASS - UNIT 4

Lesson 1

WORKSHEET

Name or ID Code ________

Teaching notes for 5th and 6th graders: Be sure to show your parents your "homemade" mass pieces and tell them what you learned in school about the weights of pennies, nickels and paper clips. Explain how you decided where to make the marks for different weights on your scale. Can you describe the difference between weight and mass

1. First, estimate and then use your spring scale to weigh (determine the masses of) the following objects.

item	estimate	actual mass (approx.)
a small rock		
several keys		
______ (your choice)		
a half cup of water		

2. An object (or combination of objects) that has a mass of approximately 1 gram is ____________.

3. Name 3 other objects that would be measured in grams. ________, ________, ________.

MASS - UNIT 4

Lesson 2

Objectives

The student will know the terms milligram and kilogram, their symbols, relationships to the gram and will have a good idea of the weight of each.

When given a measurement in grams and milligrams, the student will be able to express the measurement in either grams or milligrams.

When given a measurement in grams and kilograms, the student will be able to express the measurement in either grams or kilograms.

Materials

Worksheets - 1 per child

Activities

1. Lead a class discussion which elicits the need for units of measure that are larger and smaller than the gram. Emphasize that the kilogram is used more commonly than the gram because most objects in common use have a mass of more than 1000 grams. Discuss the relationships between, and symbols for, milligram, gram and kilogram. Review some of the rules of correct metric practice at this time (see last lesson).

2. Exhibit items such as a quart of milk, a pair of shoes, two boxes of cereal that have masses of approximately one kilogram. "Brainstorm" other items whose masses would be measured using milligrams, grams and then kilograms.

3. Discuss methods of combining milligrams and grams into one expression as well as methods of combining kilograms and grams into one expression. Make sure children understand that the combined terms, in each case, must be written in thousandths when using only the larger unit. (example: 5 g 35 mg is equivalent to 5.035 g)

4. Work through problems similar to those on the worksheet, to the extent you feel appropriate.

MASS - UNIT 4

Lesson 2

WORKSHEET

Name or ID Code ___________

Teaching notes to 5th & 6th graders: Be sure to discuss:

1. The number of milligrams in a gram.
2. The number of grams in a kilogram.
3. Uses of grams, milligrams and kilograms.
4. How to change an expression written in grams and kilograms to an expression using only grams or kilograms.
5. How to change an expression written in milligrams and grams to an expression using only milligrams or grams.

---

1. Circle the item below that would be measured in kilograms. Underline the one that would be measured in milligrams. (The remaining items will be measured in grams)

A pro football player	A car
A grain of rice	A dime
A large dog	Chocolate candy bar
Bag of lawn fertilizer	Box of cereal

2. Name an object that weighs approximately 1 kilogram (HINT: A kilogram = 2.2 pounds) ___________

3. Change these expressions to one unit as indicated:

3 kg 357 g	=	________	g
[illegible]2 kg 5 g	=	________	g
2 g 795 mg	=	________	mg
5 g 29 mg	=	________	mg
4 kg 29 g	=	________	kg
5 kg 8 g	=	________	kg
16 g 574 mg	=	________	g
7 g 17 mg	=	________	g

Lesson 3

Objectives

The student will know that 1 milliliter of water has a mass of 1 gram and that 1 liter of water has a mass of 1 kilogram.

The student will know that since 1 cubic centimeter is the same as 1 milliliter, then 1 cubic centimeter of water has a mass of 1 gram.

Materials

For demonstration:
- 1 scale (may be a spring scale)
- Graduated cylinder
- 2 paper cups
- Water

Worksheets - 1 per child
2 sheets per child for "Mass Diet" game, dice
Chart comparing weights in pounds and kilograms - 1 per child
mL eyedropper (several per class)

Activities

Demonstrate the following procedures, to be repeated at home by the students:

1. Use an accurate scale to demonstrate that one milliliter of water weighs one gram.

2. Using measuring spoons, a milliliter eyedropper and/or a measuring cup, pour a pre-determined amount of water into the cup of a spring scale. Use the chalk board to note the amount of water and its weight on a chart. Repeat this procedure several times. (Note: a tablespoon has a capacity of 15 milliliters. A teaspoon has a capacity of 5 milliliters).

3. Discuss the relationships between metric measures of mass and capacity. Make sure students understand that 1 milliliter of water has a mass of 1 gram and that 1 liter of water has a mass of 1 kilogram. They should also relate these to volume measurements: One cubic centimeter of water has a mass of 1 gram.

4. Distribute the chart comparing weights in pounds and mass in kilograms, and also the "game board" (ditto) for playing mass diet. Ask children to complete worksheets and play the game.

Notes to the Teacher

1. Because children have already brought their scales and measuring cups home, it will be easier to demonstrate this procedure (Activity #2) in school and have the children repeat it at home.

2. While we are not working with conversion factors, the chart seems to be the only practical method of allowing children and parents to determine their weight in kilograms.

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MASS - UNIT 4

Lesson 3

WORKSHEET

Name or ID Code ____________

Teaching notes to 5th & 6th graders: Repeat the experiment performed in class today in order to complete the chart in question #1. You will need your spring scale, measuring spoons and measuring cup.

---

1. Use your measuring cup and/or measuring spoons to place a measured amount of water into the cup of your spring scale. (Remember: a teaspoon has a capacity of 5 mL; a tablespoon has a capacity of 15 mL). Record the amount of water and the mass indicated by the scale. Repeat this procedure with different amounts of water. Suggestion: Do not use scale to weigh less than 20 milliliters of water.

Amount of Water	Weight
_____ mL	_____ g
_____ mL	_____ g
_____ mL	_____ g
_____ mL	_____ g

(Any difference between the two numbers results from inaccuracies in the scale or measuring cup).

2. An accurate scale would show the mass of 5 milliliters of water to be ____________________.

3. Use the comparison chart (or a scale, if available) to find your metric mass. ________________________.

4. Play "Mass Diet."

Lesson 4

Objectives

The student will be able to solve appropriate word problems involving metric terms.

The student will know the term metric ton, its symbol and relationship to other metric units of mass.

Materials

Worksheets - 1 per student

Activities

1. Review the method of combining metric units used for measurement of mass.

2. Demonstrate and discuss the solution of several word problems. You may wish to have the children work in groups, assigning a different problem to each group. A member of each group would be responsible for explaining the solution to the class.

3. Discuss the term metric ton and its relationship to other metric units.

MASS - UNIT 4

Lesson 4

WORKSHEET

Name or ID Code ____________

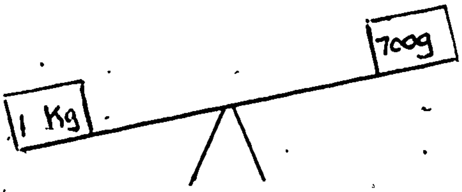
1. What is the total weight of John, Jose, Louise, Mary and Alex if John weighs 34 kg, Jose weighs 40 kg, Louise weighs 45 kg, Mary weighs 36 kg and Alex weighs 43 kg? ________

2. John baked five dozen cookies. If each cookie weighs 5 grams, what is the total weight of all his cookies? ________

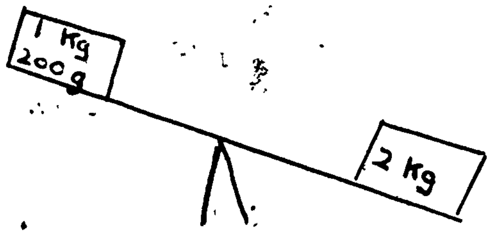
3. If a kilogram of butter costs $4.00, how much should 500 grams of butter cost? ________

4. Make these scales balance: Draw a new diagram or indicate the weight to be added to the left or right side.

A.



B.



5. A suitcase weighs 25 kilograms; a parcel weighs 500 grams. If you lift both, how much are you carrying? ____________

6. Which expression is written correctly? ____________

a) 250 kg   b) 250 Kg   c) 250 kg.   250 Kg.

TEMPERATURE - UNIT 5

Lesson 1

Objectives

Given a common situation (example: "You are outside building a snowman") and several choices of temperature, the student will be able to identify the celsius temperature most closely associated with the situation.

The student will know that water freezes at 0° C and boils at 100° C

(Note: If an adequate supply of celsius thermometers is available for instruction, the following objective will be included). The student will be able to approximate and then verify the temperature of a common situation to the nearest whole degree using a celsius thermometer. Example: the temperature of this room.

Materials

celsius thermometers - at least 6 per class (optional)
Ditto sheet to make temperature comparisons - 2 per student
Worksheet - 1 per student

Activities

1. Review the method of interpretting markings on a celsius thermometer. (For example, if temperatures are noted every ten degrees and there are nine marks between numbers, each mark represents one degree.)

2. Briefly discuss the history of the celsius thermometer. It was named after its inventer Anders Celsius in 1742, who divided the range between the freezing and boiling points of water into 100 equal parts. The thermometer was known as centigrade until 1948 when the name was officially changed to celsius to avoid confusion with the term centigrade (a term used to measure angles in some countries). Discuss the symbol for celsius temperature.

3. Distribute the ditto sheet which allows students to make comparisons between celsius and farenheit temperatures. Discuss the sheet and work with the children to follow the directions.

The correct answers for this exercise are as follows:

a) freezing point of water - 0° C
b) boiling point of water - 100° C
c) an autumn day - 5° C
d) comfortable room temperature - 23° C
e) normal body temperature - 37° C
f) a fever - call the doctor - 39° C
g) a good day for the beach - 35° C
h) a good day for playing in the snow - 10° C

4. Write the following poem on the board. Ask the children to copy it so they can discuss it with their parents.

30° C is hot
20° C is nice
10° C is cold
And 0° C is ice

Note to the Teacher

If you have one or several celsius thermometers, you may give all the children an opportunity to guess and then read room temperature. If possible, you might also give them a chance to take an outdoor reading.

TEMPERATURE COMPARISON

DIRECTIONS

Draw lines across both fahrenheit and celsius thermometers to show a realistic temperature for each of the following situations. Write the celsius reading and the letter of the situation next to each line that you draw. (The first one is done for you).

a) freezing point of water

b) boiling point of water

c) an autumn day

d) comfortable room temperature

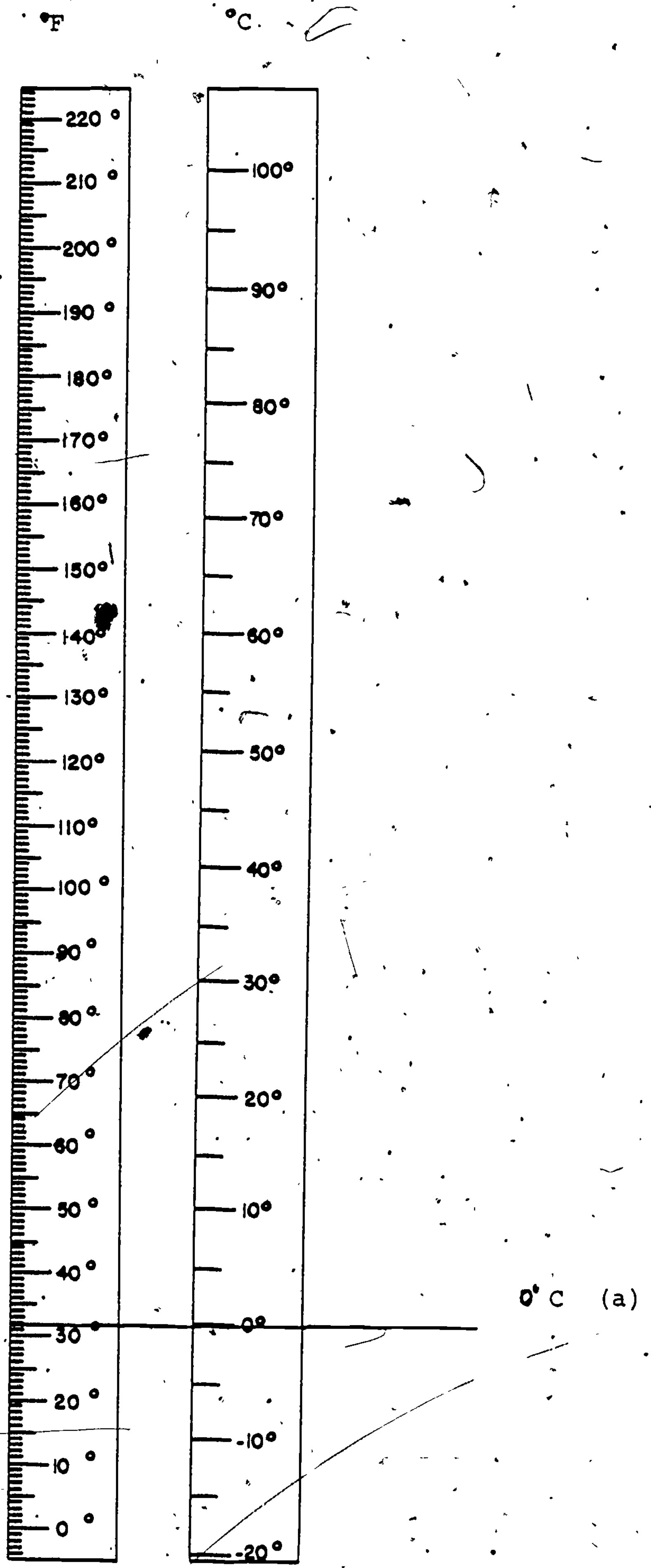
e) normal body temperature

f) a fever - call the doctor

g) a good day for the beach

h) a good day for playing in the snow

TEMPERATURE COMPARISON



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Lesson 2

Objectives

Students will be able to record and read information from a temperature graph.

The student will know that temperature measurements can go below $0^{\circ}C$ and above $100^{\circ}C$.

Materials

celsius thermometer
Styrofoam cups
Ice
Salt (about 10 cm per thermometer)
Hot plate and pan to make boiling water - 1 per class
(Note: The amount of materials needed will depend on the number of thermometers available. See below)

Activities

1. You may do the following activities as demonstrations or divide the class into smaller groups, depending on the number of celsius thermometers you have available. (You may wish to reserve experiments which use boiling water for demonstration under any circumstances.)

Pour some boiling water into a cup. Fill a second cup with ice. Place the thermometer into the boiling water, noting that once the liquid in the tube stops rising, it will not go any higher, even if more water is added. Record this temperature, wait a few minutes for the thermometer to cool, and then measure the temperature of the ice. Allow 4-5 minutes for the temperature to go down. Then record the thermometer reading. Add about 10 cm of salt to a water and ice mixture (in a styrofoam cup). Note the temperature reading.

2. Distribute graph sheets to be used for recording temperatures. Ask a volunteer to obtain an outdoor temperature reading. If you do not have a celsius thermometer, obtain a reading from a farenheit thermometer and then use the diagrams on the worksheets distributed during the previous lesson to make an approximate conversion to celsius. Assign different children the responsibility for obtaining a celsius reading during the morning and afternoon of the next several days, and recording their findings on a posted graph or chart for others to copy.

3. Review celsius temperatures for "common situations," discussed during the last lesson. If necessary, review graph reading and recording skills.

4. Give children an opportunity to complete worksheets.

<u>Notes to the Teacher</u>

1. If you do not have a celsius thermometer, you may do the experiments with a farenheit thermometer and convert to a celsius scale or simply discuss the findings with the class.

2. You may wish to discuss the fact that we will have many more minus degree temperature forecasts and readings after we convert to this scale.

TEMPERATURE - UNIT 5

Lesson 2

WORKSHEET

Name or ID Code ____________

Teaching notes to 5th and 6th graders: Be sure to explain the demonstrations conducted in class to measure the temperatures of ice and boiling water. Can you describe the methods of finding an average, and also reading a graph?

1. Use the temperature graph to determine:

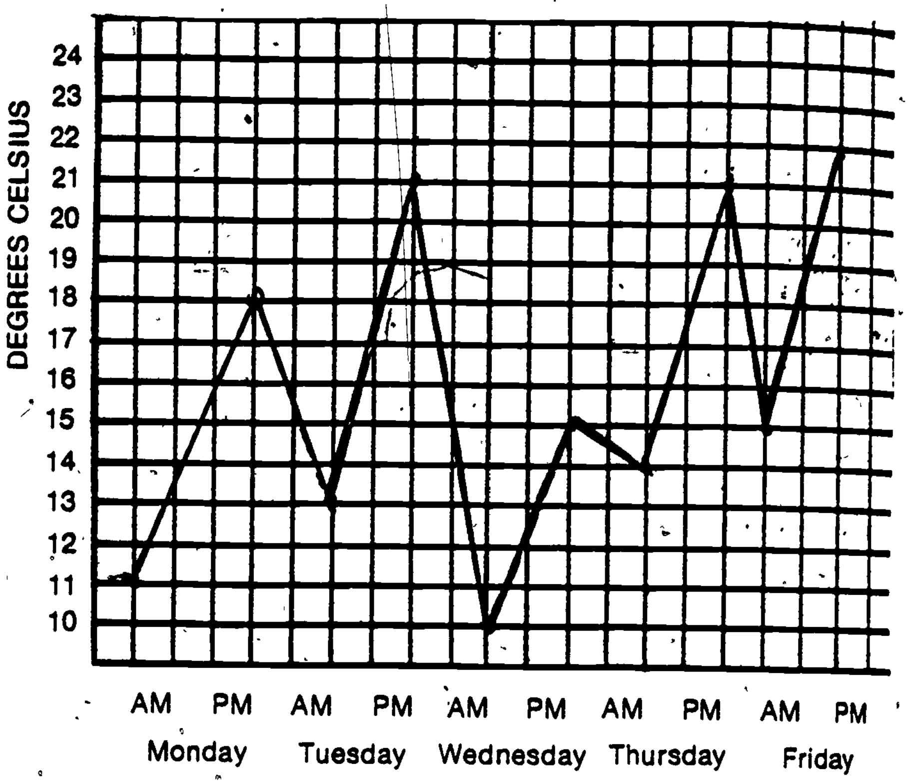
   A. Which day had the greatest change in temperature from morning to afternoon? ________

   B. Which day had the smallest change? ________

   C. What was the average temperature in the morning? ________ in the afternoon? ________

2. Describe a circumstance under which the temperature would measure below 0° C. ______________________________

3. Describe a circumstance under which the temperature would measure above 100° C. ______________________________



Review Lesson

Objectives

The student will demonstrate knowledge of correct metric practice by reading and recording metric measurements using accepted symbols and forms.

The student will be able to appreciate the simplicity, consistency and efficiency of the metric system.

The student will be able to explain the concept and value of the decimalized system.

Materials

Worksheets - 1 per child

Activities

1. Review the prefixes used in the metric system, emphasizing the consistency with which they are used for all forms of measurement.

2. Review the major rules of correct metric practice. As these have been discussed at appropriate times throughout the units, the children should be familiar with them. Rules to be emphasized include:

a) Unit names are not capitalized except at the beginning of a sentence and in titles, headings, etc.
b) The only symbol name which has been studied that is capitalized is that for liter (= L). This is to avoid confusion with numeral 1.
c) A period is <u>not</u> used after a symbol, except when the symbol is at the end of a sentence.
d) All unit names which have been studied form their plurals by adding an "S."
e) Symbols for units are the same in singular and plural.
f) In symbols or names for units having prefixes, no space is left between letters making up the symbol or the name.
Examples: mL, milliliter; mm, millimeter.
g) Do not use two units for one quantity except when needed for teaching purposes.
Example: 3.5 m not 3 m 50 cm or 3 m 500 mm
(Thus, the emphasis on learning to combine units)
h) The symbol for degree celsius is °C. Do not leave a space between the two parts of the symbol.
i) Since commas are used as decimal markers in many countries, commas should not be used to separate groups of digits. Instead, use a space to separate the group of three digits.

Refer to <u>Metric Guide for Educational Materials</u> (published by the American National Metric Council) for additional information.

3. Ask students to complete the worksheet. In your discussion after they have done so, emphasize the reasons for the comparatively short time they needed to solve the problems using the metric system. Be sure they understand the concept of a decimalized system.

Note to the Teacher

Please make certain your curriculum agrees with the rules listed above. If there are any differences, substitute the rules used in your system. (For example, in many areas, commas are accepted as a symbol for separating groups of digits.)

SUMMARY AND REVIEW

WORKSHEET

Name or ID Code ____________

The first four questions below ask you to compute answers to similar problems using customary measurements (inches, yards, pounds, ounces) and then metric quantities. Which system, metric or customary, do you find easier? ______________ Why? __________________________________

1. The length of a table is 234 inches. This is equivalent to how many yards? _______

2. The length of a table is 216 centimeters. This is equivalent to how many meters? _______

3. If you buy four pounds of butter, how many ounces have you bought?

____

4. If you buy four kilograms of butter, how many grams have you bought?

____

5. Carefully read each of the following sentences. Then add a decimal point to the number to make the sentence sensible.

   a) The gas tank of the car held 850 liters.
   b) The living room measured 550 meters by 420 meters.
   c) The average weight of the five men was 7875 kilograms.
   d) The bottle held 95 liters of milk.

6. Circle the expressions that use correct metric form.
   a) 25 l
   b) 6 cm
   c) 10 mL
   d) 35 kgs
   e) 8 m
   f) 28 kg
   g) 315 M
   h) 4° C
   i) 15 mm.

7. Place these prefixes in order from smallest to largest: kilo, deci, milli, centi.

____
____
____
____

Dear Parents,

The American National Metric Council has recently been awarded a contract from the National Institute of Education to conduct a parent-through-child learning project. Cannon Road Elementary School has been asked to participate and we are excited about the prospect of doing so.

The project will involve 5th & 6th grade students who are presently in math classes taught by____ ______________________________. Instructional activities designed to teach the metric system will be presented to students during 2-3 math periods per week for ten weeks beginning the week of 3/30/81. These activities are part of the regular instructional program and will be administered to all students. Those students whose parents wish them to participate in the research will be asked to complete pre and post tests of their metric knowledge and, after administration of the metric units, a questionnaire regarding their attitudes towards math, the metric system and this project.

A major objective of this project is to determine the feasibility of having 5th and 6th grade students teach their parents the metric system. The students will use materials they construct in class to teach basic metric concepts at home. While participation is, of course, strictly voluntary, we hope to get all parents involved in actually working with their children to learn the metric system. Parents who agree to become involved will be asked to participate in the following portions of the study:

(1) A pre and post test will be sent home to be completed by parents. Each test will take approximately 45 minutes to one hour to complete.

(2) Telephone interviews will be conducted by the project director before and after teaching of the metric activities. The interviews will focus on such information as parents' attitude toward the metric system and toward participation in this project. The interviews should take five to ten minutes.

(3) As mentioned above, children will be taught metric units in class and will bring home materials and worksheets to complete with their parents at home after each class. A metric booklet, which will serve as a reference, will also be sent home. Parents will be asked to spend approximately 30 minutes on each of two lessons per week. While worksheets completed by parents will be corrected by the project director and returned to parents, there will be no "penalty" (or record kept) for work not completed, turned in late, etc. Parents will also be asked to complete a simple sheet recording the amount of time they spend working with metric materials each week. All work completed by parents (including tests and time sheets) will be identified by code numbers, rather than name, in order to maintain anonymity throughout the project.

Because this project is designed to determine whether parents can effectively learn the metric system from their children, we would appreciate it if parents would not consult other sources of information (books or friends) while they are participating in this study. The project director will be available for telephone conferences, to discuss the project in general should parents have any questions while working on the metric units. After completion of the project, a meeting will be held at school to answer all questions and discuss the project.

All of the industrialized nations of the world with the exception of the U.S. have made a firm commitment to the metric system. In 1975, the Metric Conversion Act (PL 94-168) was signed into law by President Ford and passed by the 94th Congress. This act is voluntary, leaving the major impetus for change to affected parties. There is evidence to indicate that the general public, for the most part, is in need of education in preparation for a metric marketplace.

The parent-through-child learning project is being conducted in order to determine the effectiveness of this method for transmitting metric knowledge and also to establish a model to be duplicated in other schools. Data collected through telephone interviews, attitude questionnaires, tests and time sheets will be analyzed to determine the knowledge acquired and factors that significantly affect the learning process.

The final report, which will be submitted to the National Institute of Education in late September, 1981, will be available to all participants through the American National Metric Council, 1625 Massachusetts Avenue, NW, Washington, D.C. 20036. Names of participants will, of course, be deleted from all materials involved in this study. The names of any journals or publications which accept information regarding this project will be forwarded to participants as soon as they are known.

Mary Klein who is director of the parent-through-child learning project will be at school to discuss this program with interested parents on March 18, 1981 at 7:30 . If you are unable to attend this meeting, but wish to talk with her, please call

I would again like to emphasize my support of this program. It seems to present a wonderful opportunity for parents and children to work together to learn important concepts and information. We hope you will participate in all phases and learn to Think Metric!

Sincerely,

Principal

Permission Form

Please indicate below your choices regarding participation in this project, sign the form and return it to school as soon as possible.

Please check the appropriate boxes below in both sections.

Section I - Permission for child to participate.

/___/ My child may participate in this project. (i.e. complete a test before metric instruction and test and questionnaire after the units)

/___/ My child may not take the tests designed for this project.

/___/ I plan to attend the meeting at school on March 18 at 7:30 and will make my decision at that time.

____
Signature of parent or guardian

Section II - Indication of parent interest in participating

Please note: We recognize that at periods of time there are adults, other than ~~parents,~~ who may assume a parenting role. Any adult, therefore, who is in the home, may serve in the parenting role for the purpose of this study. (Either one or two adults may participate)

/___/ I/We would like to participate in this project (complete pre and post tests, telephone interviews, and metric worksheets). A good time to reach me for a telephone interview is ______________. My telephone number is ______________.

/___/ I/We plan to attend the meeting at school on March 18 at 7:30 and will make a decision at that time.

/___/ I/We are not interested in participating in any part of this project. (If you care to do so, please explain.)

Name(s) of participating adults

____

____

Name or ID # ____________

Pre and Post Tests

Choose the best answer for each question. Then write the letter that goes with you answer in the answer column.

Section I - Awareness

Answers

____ 1. A gram is about the weight (mass) of:

a) an apple
b) a grain of sugar
c) a paper clip
d) a cup of milk

____ 2. Which unit would be used to measure the distance between two cities?

a) centimeter b) millimeter c) kilometer d) meter

____ 3. The best estimate of the area covered by a nickel is:

a) 2 cm^2 b) 10 cm^2 c) 3 m^2 d) 10 m^2

____ 4. A square measuring three centimeters on each side has an area of:

a) 9 cc b) 9 cm^2 c) 9 cm^3 d) 9 cm

____ 5. What is the approximate weight (mass) of a mathematics textbook?

a) 1 gram b) 50 milligrams c) 5 kilograms d) 500 grams

____ 6. The major advantage of the metric system over the customary system is that:

a) The metric system is more accurate
b) The metric system has more consistent relationships between units
c) The metric system has standard units of measure
d) The metric system can be used for measuring distance as well as weight

____ 7. The ________ is the basic unit of length in the metric system.

a) meter b) liter c) centimeter d) kilogram

____ 8. Which unit would be used to express the weight (mass) of a grain of rice?

a) gram b) milligram c) kilogram d) decigram

____ 9. A measuring cup would hold about:

a) 2.5 mL b) 25 mL c) 250 mL d) 0.25 mL

_____ 10. Using the celsius scale, normal body temperature is:

a) $37^\circ C$ b) $98.6^\circ C$ c) $22^\circ C$ d) $48^\circ C$

_____ 11. Estimate the length of this line: ______________________________

a) 3.5 cm b) 6 cm c) 2 mm d) 2 cm

_____ 12. A liter of water has a mass of (weighs) about:

a) 10 g b) 100 g c) 1000 g d) 0.1 g

_____ 13. Comfortable room temperature (using the celsius scale) is about:

a) $2^\circ C$ b) $20^\circ C$ c) $40^\circ C$ d) $70^\circ C$

_____ 14. Which of the following is used for measuring the space covered by a rug?

a) meter
b) square meter
c) square centimeter
d) cubic centimeter

_____ 15. Which is closest in capacity to a one liter container?

a) pint cream
b) 1 quart bottle coke
c) gallon milk
d) 1 gallon cider

_____ 16. The height of a tall man would be approximately:

a) 2 cm b) 20 cm c) 200 cm d) 2000 cm

_____ 17. The best unit for measuring the liquid in a teaspoon is:

a) m^3 b) cm^2 c) L d) mL

_____ 18. Water freezes and boils in the celsius scale at:

a) 32° and 212° b) 100° and 200° c) 0° and 100 d) 50° and 150°

_____ 19. The volume of a small box is measured in:

a) cubic milliliters
b) cubic centimeters
c) cubic kilometers
d) cubic grams

_____ 20. Estimate the length of this line: ____

a) 7 mm b) 2 mm c) 7 cm d) 20 cm

_____ 5. One metric ton = _____ kg.

a) 50 b) 220 c) 1000 d) 2000

_____ 6. Thirty meters is equal to:

a) 30 cm b) 300 km c) 3000 cm d) 3000 dm

_____ 7. Mark the combination that m^2 represents:

a) 1 m X 1 m b) 1 dm X 1 dm c) 10 cm X 10 cm d) 10 m X 10 m

_____ 8. 1 milliliter is equal to:

a) 1000 liters b) 0.001 liter c) 0.01 liter d) 0.1 liter

_____ 9. Which statement is FALSE?

a) 500 mg is less than 1 g
b) 1500 g is less than 1 kg
c) 20 g is less than 0.1 kg
d) 3 kg is less than 4000 g

_____ 10. Which set of prefixes is in order from largest to smallest?

a) kilo deci milli
b) centi milli deci
c) milli deci kilo
d) deci milli centi

11-14. Given the distance between two walls in a room is exactly 2.074 meters, answer the following by placing A,B,C or D in the blanks below:

A meters
B decimeters
C centimeters
D millimeters

The digit 2 can be interpreted as _____
The digit 4 can be interpreted as _____
The digit 7 can be interpreted as _____
The digit 0 can be interpreted as _____

Section II - Technical Knowledge

Answers

____ 1. 700 mm = ____ dm

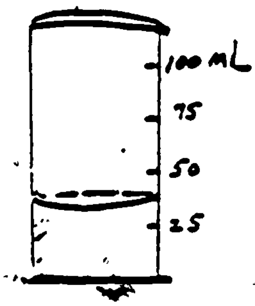
a) 7 b) 70 c) 700 d) 7000

____ 2. A milligram is the same as:

a) 0.01 g b) 0.1 kg c) 1000 g d) 0.001 g

____ 3. What is the amount of liquid in this graduated cylinder?

a) 40 mL
b) 25 mL
c) 50 mL
d) 4.0 mL



____ 4. One cubic centimeter is equivalent to:

a) 1 square centimeter
b) 1 square meter
c) 1 milliliter
d) 1 liter

Section III - Problem Solving

Answers

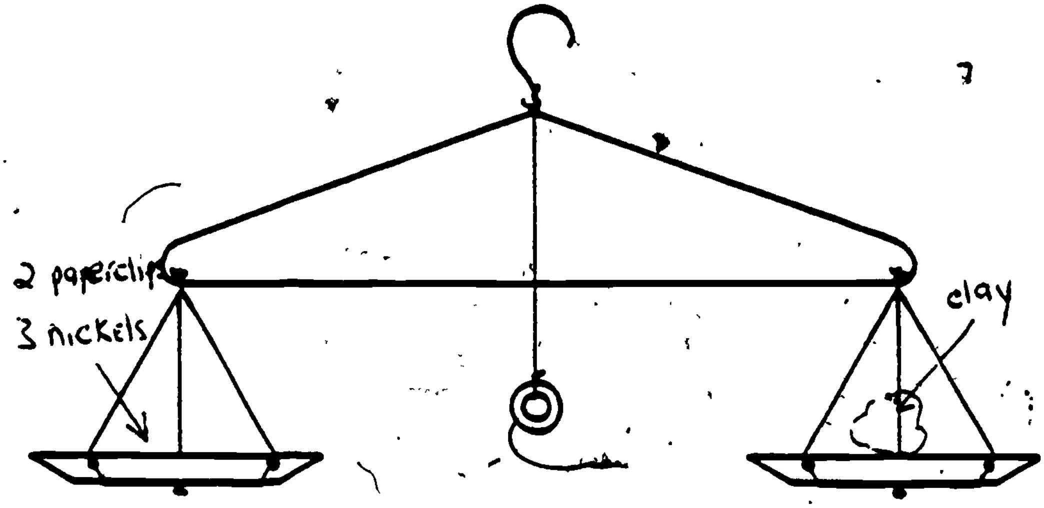
______ 1. One length of ribbon measures 2.6 meters. A second piece measures 5 centimeters. If you buy them both, how much ribbon have you purchased?

a) 2.65 meters b) 3.1 meters c) 2.605 meters d) 52.6 meters

______ 2. Compute the area of a rectangle having a length of 3.2 centimeters and a width of 9 millimeters. $(A = l \times w)$

a) 28.8 cm^2 b) 288 cm^2 c) 2.88 mm^2 d) 2.88 cm^2

______ 3. Assuming the two sides are evenly balanced, this balance indicates the weight (mass) of the clay being weighed to be (approximately)*

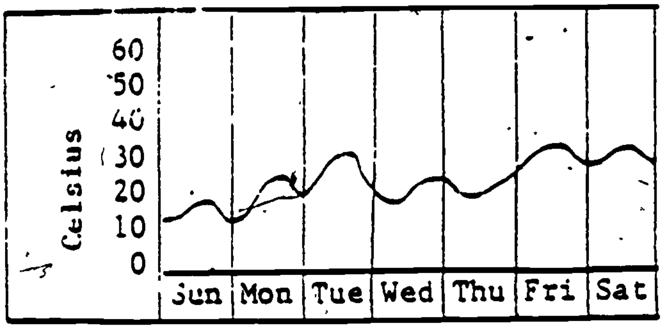


a) 10 g b) 21 g c) 7 g d) 16 g

*Note: Construction of a coat hanger balance was included in the original curriculum, but proved difficult for the children and was replaced by the construction of a spring scale.

_____ 4. The highest temperature on Tuesday was about:

a) 40 C b) 30 C c) 25 C d) 20 C



_____ 5. Find the perimeter of a soccer field that is 105 m long and 70 m wide.

a) 340 m b) 350 m c) 175 m d) 7350 m

_____ 6. A small rowboat is 1.8 m long. A large yacht is 30 m long. Find the difference between their lengths.

a) 28.2 m b) 29.2 m c) 282 m d) 28.8 m

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MARCH TELEPHONE INTERVIEW

(Administered to all parents before beginning the curriculum)

The purpose of this interview is to get an idea of your attitudes towards the metric system and towards working with your child on a project of this type. We will be interested in determining whether any changes in metric knowledge resulting from this project, either on the part of parents or children, are related to the attitudes expressed during the interviews. This interview should take between five and ten minutes. After the metric units have been taught, I will be calling you again and will be very interested in your comments regarding the project.

Before we being, I would like to take this opportunity to explain a few of the details of the project:

(1) Every lesson except one will have a worksheet to do at home. Please send these back to school after you have completed them.

(2) Within the next two weeks, your child will be bringing home a list of materials which he/she will need in order to construct metric measuring devices in class. These will be items which you robably have at home (i.e., coat hangers and milk cartons) but we would appreciate your sending them to school so he/she will be sure to have them when it is time for the lesson.

(3) Next week, your child will bring home a pre-test for you to complete and send back with him. It will probably take about one hour to complete. Please don't be alarmed or discouraged if you find it difficult! Our goal is to <u>teach</u> the metric system. We don't expect you to know anything about it but have to get an idea of exactly what you <u>do</u> know for our study.

(4) If you have any questions regarding the project, please feel free to call me. While I won't be able to answer any metric questions, I would be happy to talk with you about the project in general. In June, we will have a meeting during which time I will try to answer <u>all</u> questions and also listen to any comments you have regarding the study.

(5) Because this project is designed to determine whether parents can effectively learn the metric system <u>from their children</u>, we would appreciate it if you would <u>not</u> consult other sources of information (books or friends) while you are participating in this study.

Now let's begin the formal interview.

MARCH TELEPHONE INTERVIEW

PM1. Can you give me an idea of how much you know about the metric system?

quite a bit _____ a fair amount _____ very little _____

PM2. How important do you feel it is for you to learn the metric system?

very important _____ somewhat important _____ not important at all _____

I don't know _____

PM3. How would you feel about being involved in a learning situation in which you would learn from your child?

enthusiastic _____ not sure _____ apprehensive _____

PM4. How do you feel about participating in this project?

enthusiastic _____ not sure _____ apprehensive _____

PM5. Did you generally like math when you were in school?

yes _____ no strong feelings one way or the other _____ no _____

not sure _____

PM6. Do you participate in educational games with your child?

often _____ sometimes _____ rarely or never _____ don't know _____

PM7. Does your child like math?

yes _____ fair _____ no _____ don't know _____

PM8. How much does your child know about the metric system?

quite a bit _____ a fair amount _____ a little bit _____

I don't know _____

PM9. How does your child feel about participating in this project?

enthusiastic _____ not sure _____ apprehensive _____ I don't know _____

PM10. Have you attended some college? _____
If yes, have you graduated? _____

JUNE TELEPHONE INTERVIEW

(Administered to all parents after completing metric curriculum)

We have completed teaching the metric units and would appreciate a few minutes of your time to answer questions related to your background and your reaction of the project.

*PJ1. What is your current occupation? ______________________

*PJ2. Does your present or past occupation utilize mathematical training?
yes _____ no _____

*PJ3. How much do you feel you now know about the metric system?
quite a bit _____ a fair amount _____ very little _____

PJ4. Do you feel that you have a good concept of the sizes of the metric units (such as centimeter, gram, kilogram) that were studied?
yes _____ no _____

PJ5. Do you feel comfortable changing from one metric unit to another? (for example from centimeters to meters)
yes _____ no _____

PJ6. Would you feel comfortable buying a carpet using metric units of measurement?
yes _____ no _____

PJ7. Do you think the parent-through-child learning model is a practical method of teaching the metric system to adult learners?
yes _____ no _____

PJ8. Did you find the homework assignments difficult? Were they too long or too short?
yes _____ no _____

If yes, in what way? ______________________

PJ9. Did you generally find these lessons enjoyable? _____ Why or why not?

____

____

PJ10. If a friend had an opportunity to participate in a similar project, would you recommend that they do so?
yes _____ no _____

PJ11. What are your suggestions for improving this model?

____

____

____

____

____

* Questions used in statistical analysis

MARCH QUESTIONNAIRE

(Administered to all children before beginning the curriculum)

CMQ1. How do you feel about being involved in this project (in which you will teach your parents the metric system)?

enthusiastic _____ not sure _____ I'm not happy about it _____

CMQ2. Do you usually like math?

yes _____ no strong feelings one way or the other _____ no _____

(If you wish to make comments about the last two questions, please write them here.)

COMMENTS

JUNE QUESTIONNAIRE

(Questions added to post-test completed by children and discussed during group interviews)

*CJQ1. Have you enjoyed teaching your parents the metric system?
yes _____ no _____

CJQ2. Please write "yes" or "no" next to the activities below that you particularly liked or disliked. (You may leave all or some of them blank, if you wish.)

Construction of folding meter stick _____
Construction of decimeter cube _____
Construction of milk carton liter _____
Construction of displacement bucket _____
Construction of coat hanger balance _____

CJQ3. If your friend had a chance to participate in a project such as this one, what would you advise him or her to do? Why?

____
____
____
____
____

*Question used in statistical analysis

Appendix 8

Time Sheet
(for parents)

I.D. Number ______________

Directions: Please keep a record of the time you spend working on metric activities during the next ten weeks. (If teachers decide to teach three, rather than two lessons per week, the units will be completed sooner than indicated below.) We are interested in determining whether the amount of time parents spend on these units affects the knowledge they acquire. Remember that your name will not be written on anything related to this project. Please try to make this as accurate a record as possible. Thank you.

Week of	Space for Notes	Total no. of minutes per wk.
March 30	Tues. 30 min. Sun. 20 min. Thurs. 10 min.	50 (sample)
March 30		
April 6		
April 13		
Easter Break		
April 27		
May 4		
May 11		
May 18		
May 25		
June 1		
June 8		

Please note: If both parents are working on this project, you probably will choose to complete the worksheets at the same time. Even so, please maintain individual time sheets. Please return this sheet to school after all lessons have been completed.

Pearson's Correlations, Pre- and Post-Test Sums, Parents and Male Children, Two-Parent Families:

	PRESC	POSTSC	PRESP1	POSTSP1	PRESP2	POSTSP2
PRESC		.8904 (.002)	.0629 (.441)	.0814 (.424)	.098 (.409)	.3715 (.182)
POSTSC			-.1083 (.399)	-.2649 (.263)	.1582 (.354)	.3971 (.165)
PRESP1				.7947 (.009)	.5087 (.099)	.1149 (.393)
POSTSP1					.3851 (.173)	.1806 (.334)
PRESP2						.4563 (.128)

(n=8)

Pearson's Correlations, Pre- and Post-Test Sums, Parents and Female Children, Two-Parent Families:

	PRESC	POSTSC	PRESP1	POSTSP1	PRESP2	POSTSP2
PRESC		.7165 (.010)	-.1706 (.319)	.0497 (.446)	.5283 (.058)	.5794 (.040)
POSTSC			-.2523 (.241)	-.0707 (.423)	.1402 (.350)	.1478 (.342)
PRESP1				.8950 (.0001)	-.0890 (.403)	.4236 (.111)
POSTSP1					.0816 (.411)	.6101 (.031)
PRESP2						.6684 (.017)

(n=10)

Pearson's Correlations, Pre- and Post-Test Sums, Parents and Male Children, One-Parent Families:

	PRESC	POSTSC	PRESP	POSTSP
PRESC		.7106 (.003)	.3707 (.106)	.4027 (.086)
POSTSC			.0588 (.424)	.0393 (.449)
PRESP	(n=13)			.8469 (.0001)

Pearson's Correlations, Pre- and Post-Test Sums, Parents and Female Children, One-Parent Families:

	PRESC	POSTSC	PRESP	POSTSP
PRESC		.6161 (.007)	.0229 (.468)	.2151 (.221)
POSTSC			.0986 (.363)	-.0141 (.480)
PRESP	(n=15)			.6143 (.007)

Letters giving permission to include published material in the curriculum.

WAYNE-WESTLAND COMMUNITY SCHOOLS

project metric

450 SOUTH VENOY, WESTLAND, MICHIGAN (313) 326-6686

58165

"THE SYMBOLIC NUMBER 10 SUGGESTS A COMPLETE CHANGE IN ALL DIRECTIONS OF LIFE TOWARD THE METRIC SYSTEM"

Thomas Yack, Director

Frank Higgins, Assistant Superintendent
For Curriculum

August 4, 1981

Dear Ms. Klein,

Thank you for your letter of July 21, 1981 describing the parent-through-child learning project and your request for permission to include Project Metric's desplacement bucket and spring scale in your publication.

The project would be flattered to have the two devices includeded in your upcoming publication. I've also taken the liberty of including a complete set of Project Metric's Mini-Metric Lessons. These lessons were designed to be taken home by elementary students and completed with the aid of their parents. I hope you find the lessons helpful.

Sincerely,

Thomas Yack

Director, Project Metric

ESS INC.

EDUCATIONAL SUPPORT SYSTEMS, INC.

1?? WILLOWBROOK ROAD • STATEN ISLAND, NY 10314 • (212) 698-0931 • 761-3916

Directors
Dr. Barbara Berman
Dr. Fredda J. Friederwitzer

August 4, 1981

Mary W. Klein
Project Director
American National Metric Council
5410 Grosvenor Lane
Bethesda, MD 20014

Dear Ms. Klein:

Thank you for your letter of July 7, 1981 in which you requested permission to use the chart from "The Erratic History of Metrics".

Enclosed please find an updated version of the chart which you have our permission to use. The credit line should read:

"The Erratic History of Metrics" by Drs. Barbara Berman and Fredda J. Friederwitzer, 1981, Educational Support Systems, Inc.

Sincerely,

Barbara Berman, Ed.D. Fredda J. Friederwitzer, Ed.D.

BB/FJF:mp
Enc.

AMERICAN INSTITUTES FOR RESEARCH
IN THE BEHAVIORAL SCIENCES
P O Box 1113, 1791 Arastradero Rd., Palo Alto, Ca. 94302 ● 415/493-3550

July 13, 1981

Ms. Mary Klein
American National Metric Council
5410 Grosvenor Lane
Bethesda, Md. 20014

Dear Ms. Klein:

I have checked the rights status of the activities you want to use from Make Your Own Metric Measuring Aids for your parent-through-child learning project. Only one of the activities, the Decimetre Ruler on page 3, seems to have originated with us; you have AIR's permission to reproduce the Decimetre Ruler for your project.

The other four activities originated elsewhere, so you will need to get the permission of the originators to reprint. Page 38 of Make Your Own Metric Measuring Aids gives the addresses of the originators. They are as follows:

Folding Metrestick	page 2	Brooklyn College Metric Teacher Training Program
One-millilitre Container	page 18	Southeastern Oklahoma Metric Education Project
Displacement Bucket	page 21	Wayne-Westland Community Schools
Spring Scale	page 31	Brooklyn College Metric Teacher Training Program

We're happy to know our booklet has been of use to you. Perhaps, in turn, you could send us a copy of your final report when it is published.

Sincerely,

Nancy K. Hull

Nancy K. Hull
Permissions

Southeastern Oklahoma State University
Durant, Oklahoma 74701, 405-924-0121
Mathematical Sciences

20 August 1981

Ms. Mary W. Klein, Project Director
American National Metric Council
7410 Grosvenor Lane
Bethesda, MD 20014

Dear Ms. Klein:

Your request for permission to reproduce the directions for the ONE-MILLILITRE CONTAINER has been forwarded to me by the staff at Oklahoma State University. You may reproduce the item. I would, however, like the name of my university, Southeastern Oklahoma State University, mentioned in conjunction with the publication. The USOE Metric Education Project which produced the materials from which this was taken was located at Southeastern Oklahoma State University, not Oklahoma State University. I must also stipulate that no editorial changes be make without my approval.

Sincerely,

Dr. Paula Platter

Brooklyn College *of the City University of New York*

Bedford Avenue and Avenue H Brooklyn, New York 11210

School of Education

August 4, 1981

Ms. Mary Klein
American National Metric Council
5410 Grosvenor Lane
Bethesda, Md.

Dear Ms. Klein:

In your July 21 letter you requested our premission to include sections of our Make Your Own Metric Measuring Aids (folding meter stick, and spring scale) in your Project's final report. You have our permission to do so.

For your information I have enclosed a copy of our metric booklet "Teaching Measurement in the Metric System: Length and Area " and a sample of our revised folding meter stick which we have reproduced on cardstock for our workshop participants. Page 17 of the metric booklet contains a master for this folding meter. You may include this page 17 in your report if you feel it is appropriate.

Thank you for your interest in our Project-developed metric aids.

Sincerely,

David J. Fuys
Brooklyn College Metric Project

Appendix 11

*APPENDIX 11 "THE METRIC SYSTEM DAY TO DAY" REMOVED DUE TO COPYRIGHT RESTRICTIONS.

NIE CONTRACT CONSULTANTS

Martin Johnson is an associate professor of mathematics at the University of Maryland. He is also the director of the Arithmetic Center and coordinator of the Mathematics Education Faculty.

Peter Thall is an assistant professor in the Department of Statistics at George Washington University. He has provided statistical consultation on numerous projects, including work for Wheeler Industries, Charles R. Mann Associates and the C&P Telephone Company in Washington.

Clarice Walker is an associate professor at the Howard University School of Social Work. She serves as chairperson of Family and Child Services at Howard and as senior consultant to the National Black Child Development Institute.